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The Michigan Engineers' Annual

CONTAINING . . .

The Proceedings of the Michigan Engineering Society for 1890.

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DETROIT, - MICHIGAN.

93

MICHIGAN

ENGINEERS' ANNUAL

CONTAINING THE

PROCEEDINGS

OF THE

MICHIGAN ENGINEERING SOCIETY

FOR 1890

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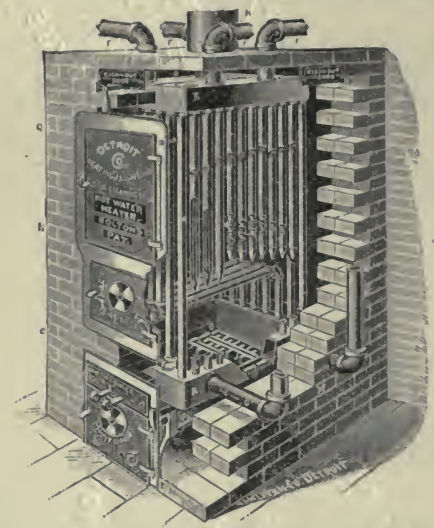
WILLIAM C. GAGE & SON,
BATTLE CREEK, MICH.

Bolton Hot Water Heater

Is the Best that has been devised for Safely, Economically and Comfortably warming Modern Dwellings of the best class, Greenhouses, Hospitals, Schools, and other Public and Private Buildings.



Its VERTICAL CIRCULATION renders its action PROMPT AND RAPID.

Its FIRE SURFACE is the largest in proportion to GRATE SURFACE.

NO BOLTED, FLANGED OR PACKED JOINTS, therefore CANNOT LEAK.

ITS BRICK CASING ENTIRELY PREVENTS LOSS OF HEAT IN THE CELLAR.

WROUGHT IRON, therefore CANNOT CRACK.

Latest from Manitoba — 80° Above Indoors 45° Below Zero Outside.

WINNIPEG, Man., Sept. 2, 1889.

DEAR SIRS:—The BOLTON BOILER I have fitted up for a party in this city has proved itself to be the most economical heater in use in the city. I have also put in three in Pt. Arthur. We have had a temperature of 45° below zero and heated a wooden dwelling to a temperature of 80°.

Yours, &c., J. L. WELLS.

COMBINATION
GAS MACHINE

Country and Suburban Residences,
Schools, Factories,
Churches, Mills,
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One-half cent per hour per burner is the average cost in localities convenient to gasoline market.

Has been in use twenty years without a single accident.

It is cheaper and better than City Gas.
Cheaper and pleasanter than Electric Light.
Simpler and safer than Oil Lamps.
It gives a soft and brilliant light.
Is free from smoke and odor.
Cannot explode, and lasts a lifetime.

AUGUST 31, 1889.

I have had in use one of your Gas Machines for SEVENTEEN YEARS, put into my house in 1872. We think it a PERFECT MACHINE for lighting.

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SEND FOR CIRCULARS.

DETROIT HEATING AND LIGHTING CO.,

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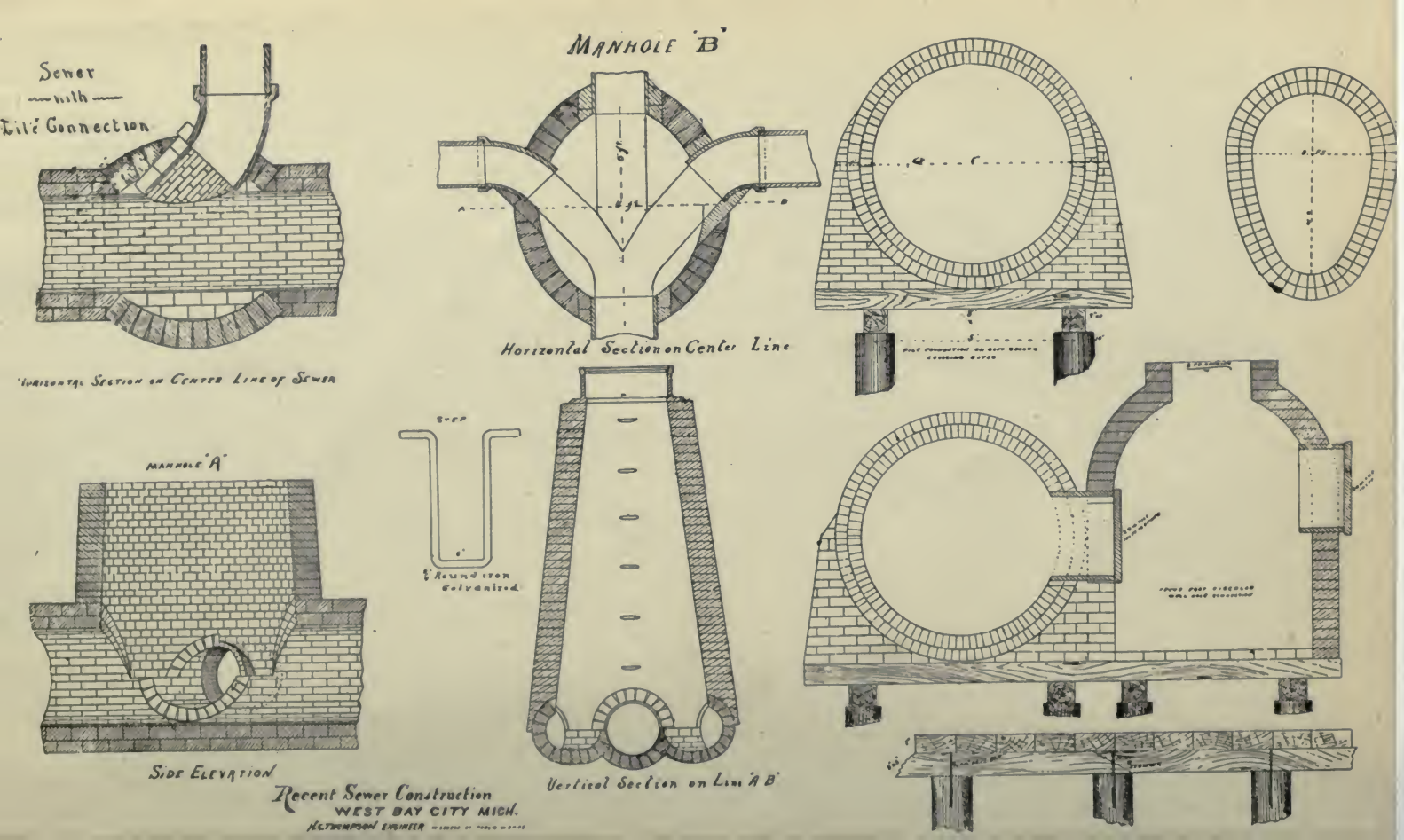
Sewer
—with—
Tile Connection
Horizontal Section on Center Line of Sewer
MANHOLE 'A'
Side Elevation
MANHOLE 'B'
Horizontal Section on Center Line
Vertical Section on Line 'A B'
Recent Sewer Construction
WEST BAY CITY MICH.

MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Eleventh Annual Convention, held at Detroit, January 21-23, 1890.

SEWERAGE OF WEST BAY CITY.

DURING the years 1888–89, a system of sewers was designed and constructed by the Board of Public Works, a short description of the same being attached.

The outlet is into the Saginaw River, and lying back from the river is a low, marshy tract of ground running parallel to and about two thousand feet from it. Between this bayou and the river is a sand ridge upon which the business part of the town stands. The principal object sought after was to drain the bayou and in connection therewith to establish a system that would meet the requirements of drainage for all time to come. The Board of Public Works divided the city into districts and made plans for a main sewer.

The main sewer is constructed of double rings of brick, and all district and lateral sewers of socket tile. The outlet is a box 5x5 feet inside, made of 6x6 inch Norway drift, bolted together with a 4 inch top and bottom spiked to the sides. The box is about 175 feet long, and at the lower end the bottom is 18 inches under ordinary water level. When solid ground was found, the brick-work was started and excavations made, by the use of pumps in keeping out the water, as the bottom was below the surface of the river, and the soil sharp sand. A wood invert was provided to shape the sides and bottom of the trench, and the brick laid thereon for a distance of about 600 feet, when clay was found of sufficient hardness to be shaped by lines and templets to receive the brick. The sewer from the river to the bayou is 5 feet inside, round, a distance of 3000 feet, built on a grade of 1 foot in 2000 feet. In this distance there are two curves of 80 foot radius and there

is practically no change in the velocity around them. At the bayou there was no bottom solid enough to build on, and piles were driven 24 feet, sawed off and timbers laid thereon for a foundation. After intersecting the bayou, the size and shape was changed from round to egg shape, 36x54 inches, and this size continued on a grade of 1 foot in 1000 a distance of 2900 feet, where, after making another angle and crossing the bayou a second time, the size was again reduced to 28x42 inches which size was continued 2500 feet. The average depth of the large sized sewer was 19 feet; in some places being as deep as 23 feet and in sand. Manholes are built at intervals of about 300 feet, or at every crossing.

The main district sewers will be 18 inches in diameter with 12 inch laterals and 6 inch house connections, and will be on a grade of from 1 foot to 3 in 100, which I think will be sufficient to be self-cleansing.

The brick were hard burned and tested for lime, etc., by being immersed in water until thoroughly wet, and then laid by experienced men with Buffalo cement and sharp sand in proportion of 1 to 2.

The entire cost of main sewer was about $50,000.00, for which bonds of the city were issued.

H. C. THOMPSON,
City Engineer, in charge of Sewer Construction.

SURVEYS MADE

— FOR —

Railroads, Water Supply, Sewerage

AND MUNICIPAL PUBLIC WORKS.

H. C. THOMPSON,

Civil Engineer and Surveyor. County Drain Commissioner.

WEST BAY CITY, MICHIGAN.

PERSONAL REMINISCENCES OF RANDOLPH NUTTING.

SOMETHING like twenty years ago, the Highway Commissioner of Pavilion, Kalamazoo County, Michigan, came to me to get me to survey the line of a highway that they wished to lay out in that township. The man said:—

"We have been in the habit of employing Randolph Nutting to do our surveying in that part of the county, and I have had him at work on this job for a week, without accomplishing anything. I can't stand it any longer and I wish you would go and run out the line."

"What is the matter with it?"

"Oh, nothing, only old Randolph has got cracked on religion. He always was a little off in the upper story, and now he is worse than ever. I got him out to run the line, and the first thing he did was to get down on his knees in the dirt and pray. Then he measured his chain to see if that was right and then he prayed again."

"What did he measure his chain with?"

"Oh, with a two foot-square. Then he went to get a corner to work from, and he spent the whole day digging and praying and puttering around that corner. Next day he began to run the line, but he had not gone more than forty rods when he had to get down and pray again and then go back and measure it over. Then he was dissatisfied with the starting point, and went back and fussed and dug and prayed over that, and so he kept going for a week."

I found it about an hour's work when I got there. It was not the first time I had heard of the eccentric surveyor, Randolph Nutting, or "Old Randolph" as he was more familiarly called, although I had never seen him.

A winter or two after that, I was employed to survey a section in a thinly settled tract in the southeast part of the county. It was nearly all heavily timbered with beech and maple, and cut up with long stretches of black ash, willow and tamarack swamp. There was a light snow on the ground, and as we were passing through a piece of low land, I noticed a track in the snow leading up to a large, fallen, hollow sycamore tree. Thinking it some hunter's track, I followed it to the tree and looking into the hollow at the butt, I saw a rude old surveyor's compass, Jacob's staff and chain hid away in it.

"Hello," said one of the men, who was with me, "That is old Randolph's kit. He has been at work all alone over in

the big willow swamp, running out a section line. The willows are terrible thick over there, and he has been at it for more than a week, cutting lines through with his hatchet and setting stakes. He has got the brush trimmed out pretty near a rod wide for a mile, and stakes set up as high as his head every ten rods."

"Who is he at work for?"

"Oh, he is doing it on his own hook. He thinks they ought to have the line run out, and likely he is out of money, and when he gets it done he will call on them for pay."

"But will they pay him?"

"Oh, yes, the old fellow has got to be taken care of somehow, and you can't give him anything. He won't take it. He only charges ten shillings a day and we may as well give it to him that way as any other. Besides, he is terrible accurate. He won't set a corner nor tell you anything about it till he knows it is right to a sixteenth of an inch. When he measures a line everything has got to be just so. It has got to be measured straight, and the chain has to be perfectly level. He always measures a line twice over, and if it does not come out alike to a quarter of an inch he will keep measuring it over till it does."

"Where does he stay?"

"Oh, he has got a hut over in the edge of a swamp about three miles from here that he makes a home of, but he goes all around the country. Sometimes he sleeps in barns or in hollow logs in the woods. Most any of us will keep him over night, or give him a meal, if he would take it, but as I said, you can't give him anything. If he has any money he will come to the house for a meal or lodging and he always pays just ten cents for a meal, no more and no less. If he is out of money and work, he will lay out around the stacks, or in a hollow log, till he can get a job. He will go to running a man's line, where he thinks it ought to be done, whether they hire him or not. Most of us take him in and board him while he is at it, and maybe furnish him some help. He generally manages to board out his wages before he gets through with a job."

"Has not he any family or friends?"

"Only some sisters out near Vicksburg, and he won't live with them, or take anything from them without pay, anymore than from anybody else. They say he was disappointed in love when a young man, and has been cracked ever since.

"I noticed his tools were not in very good order. I should not think he could work with them."

"Oh, well, there are some of the boys that are always playing some trick on him, and they have just about spoiled his compass several times. He hardly ever uses a chain. He takes a piece of light wire four rods long, and puts handles on, and uses that to measure with. It is so light he can straighten it right out, and it is a good deal handier than a chain. It comes handy too, when he is setting his 'rock-bounds.'"

"What are they?"

"Oh that is the way he fixes the corners. When he sets a corner that he is satisfied with, he sets out four pins quite a little way from the corner, so that when the wire is drawn straight each way between the pins it will cross exactly at the center. Then he digs a big hole from four to six feet deep, and gets the biggest stone he can find and puts into it. I have got one at one of my corners that is as big as a hogs-head. It took three yoke of oxen to haul it in a stone-boat to the corner. When he gets the stone into the hole he fills in all solid around it and then drills a hole into it six inches deep and big enough to set his Jacob's staff in. That is what he calls 'rock-bounds.'"

"Has he put in many such?"

"Quite a good many. He would have put in a good many more, but he never will put in a rock-bound unless he knows the corner is exactly right, and besides a good many folks don't want to bother with him, or to haul the stones for the corner. Of course he can't haul them himself, and if he cannot get the interested parties to haul them, he generally makes some private mark so he can tell where the corner is and lets the corner go without anything."

Soon after this conversation, some one set fire to his cabin, one cold night in the winter, just for the fun of seeing what "Old Randolph" would do. The result was that the cabin with all his notes and other contents were destroyed, and "Old Randolph" narrowly escaped with his life. After that, he laid out for a time in the woods, as I was told, until his feet were so badly frozen that he could not take care of himself, and others had to care for him. He was provided for, I knew not how, until he could get around again, when the supervisor of the town where he made it his home "put up a job on him" to get him into the poor-house. I think this was in the winter of 1869 and 70. A resolution was passed by the Board of Supervisors appointing Randolph Nutting County Civil Engineer, for the purpose of planting "rock-bounds" around the county farm. He was to receive ten shillings a day for his services,

while actually at work, and was to be boarded at the county house for ten shillings a week till the work was done. He was to have whatever assistance he required from the inmates of the county house in making the surveys. I was at the time serving my second term as County Surveyor of Kalamazoo county, and had my office at Galesburg, near which village the county farm is situated. I had never met "Old Randolph," but was posted by the supervisors as to what was being done.

One cold, blustery day in January, I sat in my office writing up my records, beside a warm and crackling fire. Outside the snow was falling thick and fast, whirling around corners and piling up in great heaps across the streets. Suddenly my office door opened and a gust of flying snow-flakes burst into the room, followed by what at first sight might have been taken for Santa Claus himself. When the door was shut, and the snow-flakes melted, I saw before me a man apparently between 45 and 50 years of age, about 5 feet, 6 inches in hight, very strongly built, as if possessing great physical power. He was meanly clad in a ragged coat, pants, and shirt without a vest. Coat and pants were in tatters; the pants were without suspenders and held up by a cord around the waist. The coat was short of buttons, and was held together by a straw rope bound around him. He had no boots. His feet were wound about with rags, and over them he wore a heavy pair of woolen stockings, into which the bottoms of the trousers legs were tucked. He handed me a paper and made known the business which brought him. The paper was signed by the chairman of the Board of Supervisors and by the County Clerk, and set forth over the great seal of the county that the bearer, Randolph Nutting, had been duly appointed County Civil Engineer to place "rock-bounds" about the county farm. He came to me for field notes and information relative to corners in that vicinity. I gave him such information as I had, and allowed him free access to the field notes to copy whatever he desired. When he had got what he wanted, he drew his chair up beside the fire, enjoying the cosy warmth, and entered into conversation. I remember now but little that he said, and only carry a vivid impression that much of it showed evidence of deep thought, and careful though not extensive reading. There was much of originality and power mingled with wild wanderings, that showed an unbalanced mind. He was certainly a better land surveyor than I was, or anyone else that I knew. He was much impressed with the idea of having been appointed County

Civil Engineer, and returned to it again and again. Once, after sitting for several minutes silent and thoughtful, he broke forth, "Now then," he said, "to study. I have been thinking over our respective offices and position, and in one respect I think they are very much like those of members of Congress. A representative in Congress is elected by the votes of the people in his district. A senator is elected by the votes of the members of the State Legislature. You are the County Surveyor. You was elected by the votes of the people of the county. I am the County Civil Engineer. I was appointed by the Board of Supervisors, and have my commission as you see under the seal of the county. Now I think my office is about as much above yours as a senator is above a representative."

He went his way. The time was not propitious for setting "rock-bounds." The ground was frozen, the weather inclement, and the paupers poor help for such a surveyor as old Randolph. I think he got an inkling of the scheme that had been worked, or suspected it, for he staid at the county house but a short time and then returned to his old haunts. I saw him occasionally after that. He put up a new cabin in which he dwelt, and continued to do surveying as he had done before. His religious fervor passed away and he was inclined to be disputatious on religious matters. He attended church and would interrupt the minister in the midst of the sermon to argue a point with him, till they were obliged to "fire him out." One day some of the neighbors, not having seen him stirring about his cabin for a day or two, went to look after him, and found him tossing about in a delirium, severely bruised and hurt, and a hole through the roof of his cabin. A physician was immediately called, but he never recovered enough to tell what hurt him. He lingered in great agony for a few days and died. I tried to get copies of the field notes made by him, but there was nothing left of any value. The accumulations of years had been burned with his cabin as before mentioned. "Old Randolph" is gone, but his memory as an honest, eccentric man, and a thoroughly accurate land surveyor, is fresh and green among his old neighbors, and the "rock-bounds" he planted will perpetuate his good works when we shall all of us have been forgotten.

F. HODGMAN.

THE GRADIENTER.

WHEN we find ourselves in possession of a good machine, one capable of a great many kinds of work, it is desirable to know something of its anatomy or parts, particularly of any weak points in it.

In our *Gradienter*, which is of great and growing usefulness, is a fallacy not generally known to engineers.

The theory of this machine—or attachment to our transits —is *that the variation in the angle of elevation of the telescope, varies strictly with the number of revolutions of the tangent screw.*

So far as the *sine*, the *chord*, the *arc*, and the *tangent* of an angle may be regarded as equal, the above law may be regarded as true ; but above $2\frac{1}{2}$ to 3° this assumption will lead us into error, as a few examples will illustrate.

"But," says the objector, "is not the triangle made by the 'distance,' and the 'reading' of the rod, as base and perpendicular, *similar* to that made by the length of the 'lever,' and the length of the 'screw,' as base and perpendicular?"

The reply is that these two triangles are always rigorously similar- and therefore proportional. But it does not follow that the successive increments of the angle of elevation of the telescope—and therefore that the successive increments of the reading of the rod, for each turn of the screw are equal. And here is the fallacy that I wish to point out.

These successive increments *are not equal*, as the following consideration will show.

With equal consecutive increments of the arc of an angle, the tangent is increased by an *increasing* increment. But in this case, the tangent is increased by a uniform increment; whence the arc, and consequently the reading of the rod, is increased by a *decreasing* increment.

The cause of the falling off of the rate of the increment of the angle of elevation of the telescope, is seen from another consideration. The screw, working in the direction of the tangent of the arc, which the lever actuating the telescope describes, the point of application of the screw slides over the external part of the secant of the angle of elevation, of the telescope, thereby *increasing the radius*, and as a consequence *diminishing* the increments due to the successive turns of the tangent screw, and as a consequence *diminishing* the consecutive increments of the reading of the rod,—*so that these readings do not vary in proportion to the number of turns given to the tangent screw*,—which is the popular theory of the *Gradienter*.

This erroneous principle always results in giving distances *too small*, except those determined with angles under about 3°, as before mentioned.

A few examples will illustrate. We will take an angle of elevation greater than usual, in order to show the error more conspicuously.

Suppose we give to the screw of the Gradienter scale, 30 revolutions,—two revolutions corresponding to 1 foot at the distance of 100 feet.

Then the theoretic angle due to the elevation of the telescope, would be 30 times the angle due to one revolution, or 8°, 35′, 50″. And the theoretic reading of the rod would be 15 feet.

The arc of this angle, to radius, 100 feet, would be 15,050 feet.

Regarding this amount of arc as so much tangent (as we must since it is measured in the direction of the tangent), we find the corresponding angle of the elevation of the telescope to be 8°, 32′,—thus showing a falling off of 3′, 50″ from the estimated elevation of the telescope,—and a consequent falling off of .115 feet in the reading of the rod,—and as a further consequence, a falling off of 11.5 feet per 100,—or 115 feet falling off per 1000, in the distance.

In the same manner, 22 revolutions of the screw would show a falling off of 1′, 35″ in the theoretic angle of elevation of the telescope, and a corresponding shortage of 4.6 feet per 100, or 46 feet per 1000, in the distance.

And 15 revolutions would show a shortage of 30″ in the angle of elevation, and 14 feet per 1000, in the distance —the theoretic angle of elevation being 4°, 17′ 55″.

In the same manner, 10 revolutions would have a falling off of but 10″ from a theoretic angle of 2°, 52′, with a corresponding shortage in the distance of but 5 feet per 1000.

Again if we give the Gradienter screw the number of revolutions corresponding to 90°, the telescope should be elevated to a perpendicular position, and the reading of the rod should be *infinite*, to correspond with the popular theory of the instrument.

But, on 100 feet radius, the arc described is 78.54 feet. But as this arc has been projected in the direction of the tangent, the elevation of the telescope is only that due to so much tangent, or 38°, 9′,—so wide is fact from the popular theory,—and the reading of the rod is 78.54 feet, instead of infinity.

If we should require to work up an incline of more than about 3°, we should first slack the clamp, and turn the telescope up to the given elevation, before clamping the Gradienter to the telescope. By this means we preserve the available part of the Gradienter for the reading of the rod.

It will be remembered that two years ago I presented a paper on this same topic. But after a time some further explanation was asked for, but before I could make it, our report went to the printer,—thus the article was not published.

In this treatment I have endeavored to be so full and elementary that further explanation will not be wanted.

I gave, too, a method of making corrections for angles greater than 3°, by means of a table of errors.

A better means of avoiding error is to be found in modifying our telescope. *Use the inverting eye-piece.* By this means, with a given length of tube, we may have a *greater focal length*, and as a consequence a *greater power.*

We will have, too, *more light*, because of less loss by absorption. And, with the greater focal length of object glass, we will have better *definition*, because of less spherical aberration.

With the above advantages we may *shorten* the unit of measure on the rod,—say make it .4 instead of .5 of a foot at 100 feet, for one revolution of the screw. This will help to keep the angle of elevation of the telescope within the limits desired.

H. C. PEARSONS.

BUFF & BERGER,

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No. 9 Province Court, BOSTON, MASS.

THEY AIM TO SECURE IN THEIR INSTRUMENTS

Accuracy of Division; Simplicity in Manipulation; Lightness Combined with Strength; Achromatic Telescope, with High Power; Steadiness of Adjustments under Varying Temperatures; Stiffness to avoid any tremor, even in a strong wind, and Thorough Workmanship in Every Part.

Their instruments are in general use by the U. S. Government Engineers, Geologists and Surveyors, and the range of Instruments as made by them for River, Harbor, City, Bridge, Tunnel, Railroad and Mining Engineering, as well as those made for Triangulation or Topographical Work and Land Surveying, etc., is larger than that of any other firm in the country.

ILLUSTRATED MANUAL AND CATALOGUE SENT ON APPLICATION.

INITIAL WORK ON THE MEXICAN BOUNDARY LINE SURVEY, IN THE YEAR A. D. 1849.

ENGINEERING, civil and mechanical, has made great progress within the last half of the century. The achievements of the modern engineer, bold, practical, many-sided and far-reaching, excite astonishment. In the mediæval ages such marvelous exploits would have won for him the name of wizard, and his reward most likely would have been a fiery trial at the stake.

From the advanced position attained, in the face of accomplished facts, members of this honorable Society will pardon me for asking them to go back with me to a period indeed full of interest and enterprise, but not illuminated by the brilliant light of modern science and art.

Forty years in this "rapid transit" age, when steam and electricity are prime factors, is a long step backward. The distance is immense when measured by the world's progress during that time.

In 1849 the Mexican War had closed. The newly acquired territory of California was a remote region to be reached only by sailing around Cape Horn or perilous overland journey over high mountains and across inhospitable deserts controlled by savage foes. Farther India and China were better known to the civilized world than fabulous California.

In 1848-49 the people of the Atlantic States were startled by whisperings of gold discoveries at Sutter's saw-mill, on the headwaters of the American River.

These whisperings, faint at first, and hardly credited, soon became so loud-voiced, that their echoes went resounding through the world. Then began a rush and scurry of people to the new El Dorado as had never been seen. The Crusades, precipitated by the preaching of Peter the Hermit, were nothing in comparison, as to numbers and results.

The lust of gold proved more absorbing than religious zeal. The whole world was aroused. Hosts from all lands, by devious and difficult ways, rushed for the foot-hills of the majestic Sierra Nevadas, confidently hoping to find in the golden sands, fortunes unlimited.

Meantime, portions of our army, fresh from the victorious battle-fields of Mexico, in order to take possession of this newly acquired land, in the name of the government of the United States, were slowly fighting their way across the continent or being tossed by ocean waves, in sail vessels, on the long voyage around South America. Simultaneously, or in the

winter of 1848–49, the Government organized and sent out a commission to survey and mark a boundary line, under the treaty with Mexico.

The commission consisted of Col. and ex-Governor Weller, of Ohio, Col. A. B. Gray, of Texas, the first named, Commissioner, and the second, Surveyor, under the treaty. Attached were about fifty gentlemen, surveyors, engineers, secretaries, a surgeon, and quartermaster, all civilians, drawn from many States.

Major Emery (afterward General), was chief astronomer and commandant of escort. On his staff were several young U. S. engineers and a corps of computers. The military escort was to join the commission at San Diego. San Diego, on the Pacific, was the designated point at which the survey was to begin and where the commission was to rendezvous. The route by the isthmus was the one selected to move on. At that time it was difficult to reach California by any route.

The headquarters of the commission were at New Orleans. It was no easy matter to reach even that point in those primitive days in winter. There were no railroads from Detroit to Buffalo; none from Albany to New York, direct, and very few south of Washington.

After some delay at New Orleans, the commission, with instruments, provisions and stores, finally embarked on a government steamer in January, and sailed for the port of Chagres, on the isthmus. Canoe transportation was used on the Chagres River as far as Gorgona, and mule trains thence over the mountains to the City of Panama, on the Pacific side. At that time surveys for a railroad were being made.

The commission was detained three months on the isthmus for lack of transports.

As yet, there was but one steamer on the water between Panama and San Francisco. She had sailed north not to return very soon. Her crew deserted her as soon as she reached California and hastened to the mines.

After a while the second steamer arrived from around the Horn, and took on board a detachment of the commission. The third steamer which sailed from New York after the commission had left New Orleans, under command of Captain Porter (later an admiral), put in an appearance in May. By strong pressure on the part of the government, the remainder of the anxious commission was received on board that ship.

Panama was crowded with adventurers. They were in great stress. To the unacclimated, the dirty, close-built, walled city was a hot-bed of fever. The imprudent, ill-fed,

anxious northmen sickened and died rapidly; cholera followed in their wake. This was a new disease to the nation and filled them with terror and consternation. They died by hundreds. Wailings were heard in almost every house, as when the first-born were smitten in the land of Egypt. Priests with bell, candle and incense paraded the streets; trains of powder were lighted and cannon fired to drive away this mysterious plague.

The desperate California adventurers were mad to escape from this wretched city. They seized upon every available mode of egress. Whalers, merchant ships, schooners, sloops, yawl boats and even the native dug-out canoes were pressed into ocean service as transports. It was a dire time. Strange to say some of those small boats and canoes, after months of peril and hardships, reached Lower California. The strong northwest winds prevented further progress.

The steamer which carried the writer, though crowded to suffocation almost, in due time arrived at San Diego. The voyage near the coast line of Central America and Mexico was very pleasant. The Pacific Ocean did not belie its name.

The writer's first experience of California, was a hard night spent at Point Loma, in one of those hide-houses so graphically described by Dana, in his work entitled "Two and a Half Years Before the Mast." Twenty-two thousand hides were stored therein. Though dried like horn, these cast-off wrappers of California's ancient wealth—the cattle on a thousand hills—were malodorous and the trysting place of innumerable fleas. A couch on these bullock hides was anything but a bed of roses.

The Pueblo of San Diego, at which the commission took post, lay several miles inland but still near the bay, on a small stream, dry most of the year. A little adobe-built town of low, red-tiled houses, built around the plaza. A few outside buildings completed this isolated Spanish town. The fine bay of San Diego, roomy enough for a large ocean fleet, lay in front, and beyond, the Pacific Ocean in its vast expanse. In the rear, bare, rounded hills were succeeded by distant azure mountains. These, and a salubrious climate, were the chief attractions.

The stars and stripes were floating gracefully from a tall flag staff in the plaza, and we Americans saluted the flag with joyous shouts, with some tears welling from our eyes.

The natives of the country, their habits and costumes, have been so often described, I will not dwell upon them.

There were plenty of horses and cattle feeding on the hills —the only wealth of this section.

The roll call, made about the first of June, found all the members of the American Commission present in San Diego. Several companies of U. S. troops were posted there. Many of the officers with the command, afterward in the war on the Union, became distinguished generals and freely shed their blood for their country, Emery, Heitzleman, Lyon, Whipple and others. The Mexican Commission had not arrived, but came in on the last of June. The Commissioners, a distinguished Mexican general, Garcia Conde, and Senor Salazar, surveyor under the treaty, with a large corps of surveyors and engineers and staff officials, were many of them accomplished men, speaking besides Spanish, French and English. The interpreter (each commission had one), Senor Iturbide was the son of the ex-Emperor of that name, and had been educated in Philadelphia.

The Mexican army escort was a disreputable band, without uniform, and taken from the prisons of Mexico mostly. I speak of the common soldier. Subsequently we Americans found them to be an element not of defense but offense,—more to be feared than the Indians. Many women were with them as camp followers.

On the 4th of July, the American Commission gave the Mexicans a dinner and ball. It would be hard to tell which side was most gloriously drunk—with patriotism.

At length, after long waiting, a program was formulated, and actual work on the boundary line survey begun.

According to treaty stipulations the boundary line, in general terms, was to be run as follows:—

Beginning on the shore of the Pacific Ocean, one marine league south of the southernmost point of the Bay of San Diego, thence easterly to the junction of the Gila with the Colorado River, thence up the Gila to its source, thence across to the headwaters of the Rio Grande, thence following down the middle of that stream to the Gulf of Mexico.

In passing, I beg to state that THAT is not the present boundary line between the two republics. By the Gadsen purchase, in 1853, the line was carried further south so as to include a portion of Sonora, now known on the maps as Arizona.

The camp of the chief astronomer was moved to the head of the bay, some 15 miles south of the Pueblo. The surveyor's camp was pitched near it.

The initial point of the line was to be fixed astronomically. Also the point at the mouth of the Gila.

A party of astronomers were at the same time sent to the Gila under Lieut. Whipple, U. S. Engineer, afterward General Whipple, killed at Chancellorville, Va.

A line drawn on the map from the astronomical point on the Pacific coast to the astronomical point at the mouth of the Gila, would give the course to follow and mark on the earth's surface as the true boundary line.

The surveyor, Col. A. B. Gray (later on the Confederate engineer who fortified Island No. 10 in the Mississippi River, and was accidentaly shot to death on board a transport), organized his forces for field work. His assistants were a motley group—mostly political appointees, and as innocent of surveying as sucking doves. A few were trained engineers, surveyors and draughtsmen of experience.

Mr. Gray's first duty was to measure the marine league before spoken of. A survey of the bay of San Diego had to be made in connection.

The measurement of the marine league was assigned to the writer; the survey of the bay to Charlie Whiting, a West Point graduate (later on a colonel of cavalry in the Union army).

But, before proceeding to work, Col. Gray ordered the writer to make a topographical survey of a small valley leading to the old mission of San Diego, six or seven miles from the Pueblo.

The writer chose his party from the young gentlemen who, on the voyage out, had constantly boasted of their engineering skill and experience. The instruments to be used were a common chain, compass and a level.

We started at the flag staff, the writer kindly managing the instruments until beyond the reach of critical observers in the Pueblo. Then he told his assistants to take the instruments and go ahead, nicely sketching in the topography in their field books. But no progress was made, Mr. H. at the compass being in doubt as to which was the north end of the needle. Mr. E. declared there was nothing to sketch but a straight line from one station to another, and so on. The survey was not completed, but an inglorious retreat was made to headquarters, where a game of poker restored the good nature of our skilled engineers. Comment is unnecessary.

The writer then made up another party from young men who had all along admitted that they were entirely ignorant of practical surveying. They were well educated law students

from the northern States. By a little drilling they soon became efficient workers, and in the course of time formed an admirable party. Many of our political appointees never did a stroke of work on the survey.

Perhaps you may have observed that no mention of common men has been made, and it would seem that the Commission was made up entirely of officers. This is true. There were really no "high privates." Some destitute emigrants from Texas, stranded on this shore without a penny, consented to work awhile to recuperate their finances, before going to the gold mines. The cook in our camp, who had acquired some skill in turning flap-jacks, while coming across the plains, was paid $500 per month, while the writer received $800 per year and rations, and the first assistant $1000 with a liberal supply of hard tack and *carna*. These terms were made on the Atlantic side, before the discovery of gold, and was considered good pay *there*.

During our first summer in San Diego, in Uncle Sam's employ, the embryo cities of San Francisco, Sacramento, Stockton, and others, were springing up and expanding. We were offered $1000 per month, with city lots thrown in, to go there and lay out the towns. But under these great temptations we remained true to our colors, every man. How this fidelity was rewarded by a generous, paternal government will be seen further on.

There was nothing difficult in the survey of the marine league. The country crossed by it was low, level, pasture land, dotted with clumps of sage brush. The land was cleared and leveled. A French metre chain was used in the measurements. It was carefully stretched by a spring balance. It was aligned by a theodolite, and was transferred by careful offsets. The work was done accurately but rapidly. No such precision, however, was required as in the measurement of a base line for triangulation. The initial point was soon fixed on a commanding bluff, and a stone monument set up there. Later the joint commission assembled at the place, and with some speech-making, and breaking of champagne bottles, dedicated the monument.

The Mexican surveyors were supposed to be assisting in the work on the marine league all the time. But they never took a hand in. Occasionally a few gaily dressed fellows, with jingling spurs, would ride down upon us and criticise the plebeian Americans, who would stoop to work, in pure Castilian.

From first to last, while we were there, the Mexican

surveyors did no work unless in the night time. How they amused themselves we were too busy to ascertain. But it was decidedly a one-sided survey, the whole of it. Yet we Yankees were content to have it so.

The chief astronomer, after months of "star-gazing" and reams of computations, finally *fixed* the initial point on the face of the earth to the satisfaction of all concerned. In order to do so, some nice triangulation was necessary.

His special work done, the writer spent a pleasant month or two with engineer Whiting on the survey of the bay. In that glorious climate, with cloudless skies, our duties were delightful, and camp fare good. Game was abundant,—deer, jack-rabbits, quail, and curlew could be had at all times. The waters teemed with fish, notably herring, mackerel, and rock cod. The only drawback in surveying and hunting was the fear of rattle-snakes. They abounded in great numbers in the tall grass and cactus and sage brush. We had many narrow escapes. The Mexican soldiers killed them for food.

While this work on the coast was progressing favorably, the astronomical party at the mouth of the Gila was busy star-gazing, much to the astonishment of the wild Indians.

A semi-military expedition was sent out from the coast across the Cordillera range of mountains, to explore the country and to establish a signal station, on the east side of the range, where the towering escarpments offered a wide view of the great desert and of mountain peaks on the far-away Colorado.

By preconcerted action, on certain nights, rockets were sent up from this station and at the one near the mouth of the Gila on Pilot Knob. The object was to thus determine the difference in time—longitude—between the two places. But the rockets were not seen, from some cause not explained. The distance between the two points, on the air line, was about 100 miles. So this party returned to camp, *not* covered with glory, but with fabulous stories as to hardships and hostility of the Indians.

In October, 1849, a grand effort was to be made. It was determined to send a party to the Gila, 200 miles away, across the unexplored mountains and desert, following as near as possible the assumed boundary line. Col. Gray, surveyor, was in command. The writer acted as his assistant. We were well fitted with a train of pack mules, carrying surveying instruments, blankets, and rations. The officers, cook, muleteers, guide, and four men constituted the party, escorted by a corporal's guard of infantry *on foot*. Cavalry would have been more

efficient. Our rate of progress was at all times fixed by these *foot-men*,—an absurd arrangement!

The speed of progress was timed, and it was found after several tests to be about three miles per hour. Thus was the distance from camp to camp roughly obtained. Topographical sketches were made by the writer on mule back. Sextant observations were taken at night. The invariably clear skies favored such work. Detestable work it was after a long day's march across those rugged mountains! Four or five hours sleep was all; too little to recuperate our worn-out bodies.

But the journey across the mountains was full of interest, and the air as exhilarating as wine. Grand peaks and deep gorges everywhere; some tall climbing was done and much rapid sliding. Desolation seemed to reign; the eyes tired of gazing upon the bare, broken, glaring, yellow rocks and jagged peaks. But as we struggled forward, hot and jaded, our trail would descend a narrow winding gorge and finally lead us out into a beautiful grassy valley, with a murmuring stream of sparkling water winding through it and lined on either hand by far-spreading, live oaks, whose shining, deep green foliage was very refreshing. There were many such valleys *en route*, and they afforded us delightful camping places, where we fain would have lingered many days.

As we marched, day after day, not a living thing was seen outside of our own party. There was some little shrubbery noticed outside the valleys. An occasional oak tree or rather shrub, loaded with clusters of sweet acorns, and some scrubby plum trees, were all that we noted. Once in a while a stark, leafless cactus plant obtruded upon the vision, adding to the desolation of the scenery. We found numerous *caches* filled with acorns, evidently the Indians' stores for winter. But where were the dreaded Indians we had heard so much about? Lurking somewhere no doubt. The solitudes were so profound that the sound of our own voices would often startle us. As we penetrated deeper into the recesses of the silent mountains we began to notice on commanding peaks in advance, tall, thin columns of smoke shooting up. These were the alarm fires, or signals of the Indians. They were evidently tracking and watching us. At length a bevy of these naked savages dropped into our camp. They were armed with bows and arrows, and were by no means hostile. A gift of hard-bread and tobacco increased their good nature.

They squatted around our bright camp-fires ready to snatch at any food thrown to them. When bed-time came, they were driven outside the line of sentinels. Instead of

building a fire for themselves, they would dig a hole in the sand with their claw-like hands, like a hog wallow, and crowd themselves into it for warmth. They were miserable "diggers." They disappeared in the morning, like dew, and were no more seen until the following evening.

During the night we found the air so chilly that we kept our camp-fires blazing and a pair of heavy blankets in addition to our clothing—none too much for comfort. We had no tents, but threw ourselves on the ground with feet to the fire, and a saddle for a pillow, and slept like very tired men.

Often baffled and turned from its course, the party nevertheless made steady progress eastward, coming out finally on the eastern escarpment of the mountain range. Before us lay spread out the great desert, looking through the shimmering heat waves, like a great yellow sea, stagnant and sullen. Where we stood, nothing but huge boulders and jagged peaks, crumbling and falling, met the eye. No water, no vegetation, only glaring rocks which struck terror into the stoutest heart. The air was so light that a shout, a musket shot, could be heard only a few feet. There appeared to be no break in this solid battlement through which we could escape to the desert. The situation was full of gloom and doubt. We *must* get out of this! And, after toilsome searching, a detached party found a slight break which would just let the mules crowd through. Down we plunged, the mules often sliding hundreds of feet on their haunches. As we advanced, the gorge widened, and before we had reached the plain, became a narrow valley, with signs of water. Six hours were consumed in the descent. The cool, pure air of the mountains we left behind only to plunge into tropical climate. As we defiled out of the gorge, hot, tired, ragged and parched with thirst, we suddenly struck a stream of running water—Carrizo creek. To plunge noses into it, both man and beast, was the work of a moment.

Carrizo creek is shallow; the waters well up suddenly, run a few hundred yards, over a sandy bed and then disappear,—a peculiarity of many western streams.

Resuming our march, we soon struck the emigrant trail in the desert. This Colorado desert is about ninety miles wide east and west, and was doubtless once the bed of the ocean—an extension of the Gulf of California. It is a level expanse with little vegetation. The road now passed over long stretches of clay and gravel, alternating with loose sand. Numerous dry arroyos were crossed, some of them many yards wide, with steep, clearly outlined banks—in fact, rivers without water. No water could be found. Heat and thirst became trying.

We camped the first night on the desert, without forage or water. The distress of the poor mules was pitiable. We passed numerous emigrant trains toiling toward the land of gold. They had spent six months in the wilderness; they were worn out, ragged, half starved, impoverished, almost hopeless. The splendid trains with which they started in the spring were reduced to a sorry condition. Horses, cows and mules, singly, or two of different kinds, were hitched to dilapidated wagons, or carts, extemporized from broken wagons. Some families were reduced to an ox or cow upon which their baggage was packed, while the men and women trudged slowly along through the deep, burning sands. They were objects of pity.

On the second day of the desert march we reached Salvation Camp. At this point blessed water was found; oh, how it was enjoyed. We were told that only a short time before, these springs burst out of the arid plain, as if by a miracle, to the salvation of hundreds of perishing emigrants.

The next year, hot mud springs were found there. All these phenomena were doubtless the effect of earthquakes. On our march we felt several shocks, and were almost overcome by the heat that accompanied them. The sky was like brass, the air still and hot as a furnace.

We found many hundred people resting at Salvation Camp. In the rich soil, grass had already sprung up, proving that the desert only needed water to show its fertility.

Among the emigrants we found a large corps of U. S. officials sent out to take possession of the custom houses in California. Mr. Collier was collector. A squadron of dragoons guarded the train. The whole body was in a starving condition, living on one-fourth rations. They were clamorous to be led by our new, short route to the coast. Col. Gray consented to act as the Moses to lead them out of the wilderness into the land of promise. He ought not to have assented; his duty was to lead to the Gila in the opposite direction. But the pleas of starving men were powerful. He ordered the writer to continue on to the Gila, and make the necessary surveys. The writer remonstrated, hinted that the supervision of that work, on the part of the surveyor, the only person known under the treaty, was imperative; that he would conduct the Collier expedition into California. "Oh," replied the Colonel, "YOU cannot find the way with them." The logical question followed this reply. "If I am incompetent to conduct this expedition over a fresh trail, how in the name of Sinbad, am I to get back with my own party, a

month hence?" The answer was, an order in writing, to "pull out" at 7 P. M. Sunday evening.

Obeying gracefully (*because he had to*) the writer only stipulated that he should not be bothered with the corporal's guard, which was accordingly left at Salvation Camp. Four men were selected to go with him, including a soldier, without his musket. Each person had a mule to ride, and there were several pack mules in the train to carry instruments, provisions and baggage. A rapid march was what was aimed at, hostile Indians were a secondary consideration.

Promptly at 7 P. M. the little party bade adieu to anxious comrades and departed. It was a clear, starlit night, and the commanding officer took his course by the stars—an effort to follow the emigrant trail soon proved futile. The shifting sands speedily obliterated all footprints, leaving us adrift on the desert. The march was slow, not faster than a walk. The commander had to be constantly on the alert in order to keep on his course, and prevent his sleepy, tired men from straying. Often they left the line, and often they tumbled headlong from their mules, having fallen asleep in their saddles. When it was necessary to stop the train to adjust the baggage, the idle ones would immediately fall asleep on the soft sands.

In the morning, Cook's well was reached. By digging, we obtained some brackish water with which to boil our coffee. After an hour's stop we resumed our march; we toiled and waded through the loose sand sullenly, almost hopelessly. The sun was intensely hot, and the fine, impalpable dust powder of the desert, hung to us, like a mist, filling eyes, nose, mouth and ears with dust. Even our clothing was saturated, and our sweating faces were plastered with it, so that the Indian was fair in comparison. Thirst, the greatest of all the traveler's afflictions, tormented us. The brackish water in our canteens, from Cook's well, became so tepid and slimy that we threw it away. Our lips became swollen, cracked open and let the blood run out. Our tongues became so swollen that articulation was difficult. Faces became haggard and eyes staring, through their grimy masks. Our pack animals shared in the common distress. Riding became so fatiguing that a change to foot was often resorted to, but was speedily abandoned. In the loose, deep sands a walk of a few hundred yards would exhaust one.

This dreary march was enlivened, if such misery could enliven, by numerous passing trains of weary, way-worn, starving, almost hopeless, emigrants. The route was marked by broken wagons, the irons of wagons, which had been burnt

for fuel, by trunks, boxes and furniture, by dead mules, oxen, cows and horses. Not infrequently we saw little mounds of sand with stakes at head and foot, whose purpose was unmistakable. With grim humor some American had placed a dried skeleton of a horse or ox on its feet, with head and tail erect, with a legend, "This is the way to the gold mines." Carcasses in this dry atmosphere never became putrid, but in this case in the starved animals, there was nothing to putrefy but hide and bones.

At 4 P. M., after leaving Cook's well, we struck an Indian village on the banks of the Colorado. Thrice welcome river, never was anything sweeter than this yellow flood! We were now fourteen miles from the astronomical camp at the mouth of the Gila.

But we came near not reaching that haven. The men tired and worn out, and attracted by the pleasant Pimo village, with its green pastures and cornfields, and, perhaps, by the half nude young squaws which met their gaze, were determined to stop for the night. To have done so, would probably have been death to all. There were mutinous displays, but the commander, placing his troop in front, drew his revolver and ordered it to trot for life. None too soon did we escape from the village; a buck, with hostile intent, intercepted us, and the commander had to knock him down with his horse pistol, because of presumption in seizing his bridle. We hurried up the river, in hot haste, the Indians following. But fortunately they had no horses, and were armed only with clubs.

These Indians were at heart hostile, and were only kept in check by the camp of U. S. dragoons stationed at the Gila. After this force was withdrawn, they attacked and killed a party of emigrants. Two companies of militia were sent out to chastise them, and did it so effectually as to annihilate the village.

At 10 P. M. we rode into camp at the Gila, after twenty-seven hours of continuous riding. We were heartily welcomed. Lieut. Whipple, of the engineers (in after years he laid down his dear life on the fatal field of Chancellorville), took me to his tent and fed me.

Our commander, after a hearty supper, unwashed and full dressed in his dirty suit, threw himself on the ground and slept twelve hours solid without stirring. One day was required for rest. On the second day of our arrival, a survey of the junction of the Gila and Colorado was made by triangulation. Our transit instrument was so badly jammed as to be

useless. Lieut. Whipple kindly lent his theodolite. There were no boats to be had, so Dr. Parry swam the swift stream (Colorado) and set up stakes for me at the mouth of the Gila.

Time and space will not permit of a description of this place. Suffice it to say, if there is a hotter place on the continent, in October, than at the mouth of the Gila, the writer has not found it; and if there is a land more sandy, more rocky, more sterile, more terrifically desolate, than this washed by the Colorado and Gila, geographers would have difficulty in pointing it out. Some profane person has aptly described the region as a "hell on earth." There is but one redeeming feature in the landscape, namely: the grand, jagged, many-colored, heaven-aspiring mountains, crossing the eastern horizon. These are best appreciated in the distance.

The return march to San Diego was full of toil, danger and suffering, for starvation was added to the list of hardships. We reached Salvation Camp more dead than alive. Our corporal's guard was well, but had about given us up. Col. Gray had fed the Collier party so well that no provisions were left for the surveying party. The writer subsisted for several days upon a handful of broken crackers each day, which the corporal kindly gave him from army rations. No time was lost. We pushed forward toward the sea with what energy was left.

Twenty-five miles from San Diego we reached a Spanish rancho. Here we encamped. A sheep was purchased, butchered and boiled in a camp kettle, and, as soon as cooked, was devoured at one short sitting; the whole command participating. Famished wolves could not have shown less ceremony.

At length the writer, with his little command, reached headquarters without loss of a man, beast or baggage.

On reporting to the commissioner, we found that august official lying on a cot, ill from a pistol shot. Displeasure at the untimely return of Col. Gray, with the Collier party, roughly expressed, had caused a row, in which the commissioner was shot by a revolver in the hands of Col. Gray. Pistol practice and the duello were quite fashionable in those days.

The commissioner was pleased to say to the writer that he would commend him highly in his next dispatches to Washington.

Those dispatches need not have been sent for all the good they did. Note results further on.

Thus ended the work on the Mexican boundary line survey for the year 1849. The approaching rainy season, it

was assumed, would stop the work, if there were no other reasons for suspension.

An election of two United States senators was to occur at Monterey in the winter. Col. Weller was an aspirant for one of these positions, for the new State of California. But before he left us he had been removed, or expected to be, by the new administration under General Taylor.

Col. Fremont was nominated as his successor as Commissioner, but we never had a glimpse of his distinguished person. He too had a senatorial bee in his bonnet. He cruelly left us to our fate. The grand Commission, in the absence of the high officials, was reduced to a pitiful lot of young men, quartered during the long rainy winter, in the mud hovels of San Diego, or in tents, without one cent of pay, subsisting upon hard bread and tough beef. There were no books and no amusements except gambling. Finally an agent was sent down to settle with us, giving unnegotiable *due bills* on the government at Washington. We were not dismissed, nor disbanded, nor mustered out, simply let alone. Our contract with the government required that we should have transportation home. At that time a steamer ticket to New York cost $500. No promises for the future were made. The resumption of work on the line depended on future appropriations by Congress,—so did the cashing of our due bills.

Thus incontinently "left" in a foreign land, as we looked at it, with no hard bread and beef guaranteed, there was nothing left for us to do but "move on," like poor Joe. The writer, by hoarding, after 14 months' faithful service, had money enough to buy a steerage passage on the steamer Oregon for San Francisco. He wrote to his father for redress. A member of Congress from his district was appealed to. An answer was received to this effect:—

"Whereas, your son deserted from the Commission and ran off to the gold mines, therefore, resolved, that he is not entitled to favorable consideration, but, on the contrary, should be punished."

As before stated, this base son of a worthy sire, was tempted soon after he landed in California, to desert his post, in consideration of pay at the rate of one thousand dollars per month and city lots thrown in. But he and his comrades stood by the colors until there were no colors to stand by.

Some of the methods of our Uncle Samuel are very queer indeed. No honest man will ever fall in love with those methods, or submit to them longer than possible. If Indian agents and others do, in self-defense, cheat our venerable

relative, the writer will not be the first man to vote to send them to purgatory. The gratitude of republics is inspiring.

JOHN H. FORSTER.

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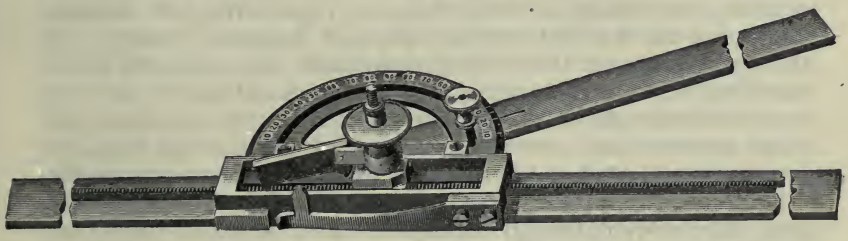

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PROGRESS OF DRAINAGE IN THE HURON PENINSULA.

A GLANCE at any map of the Huron Peninsula will show that in its central portion is the source of the following rivers, viz.: Cass River with its several branches, whose waters find an outlet in Saginaw River; Black River, with its main branch, Elk Creek, finding an outlet in St. Clair River, also the Pigeon, Barques and Willow Rivers, with outlets in Saginaw Bay and Lake Huron. Closer examination will show that this district comprises almost the whole of Sanilac County, a few of the southern townships of Huron County, bordering on Sanilac, and a few of the eastern townships of Tuscola County. At the headwaters of these several streams are uniformly found marshes or swamps, varying from a few hundreds of acres to several thousands of acres in area, and it is the reclaiming of these marshes and converting them into tillable and valuable farming lands that constitute the drainage operations of the "thumb" of Michigan. Each of these marshes is, for the most part, nearly level, but all occupy elevated plains not less than from 200 to 300 feet above the mouths of the various rivers which form their final outlets. The largest and most important undertakings, and the ones that, if any system could be followed, should properly be done first, are not yet commenced; that is, the opening of large channels at the head waters of these different streams to make the main outlets for a more thorough system of drainage. On the contrary, owing to unavoidable circumstances, the drainage goes on piecemeal, by making one small drain here and another there, as improvement and settlement of the land demands. These, for the most part, seek outlets in the sluggish head waters of the streams already mentioned.

Notwithstanding this want of system and inverted order of proceeding, the work already accomplished is very valuable, and is, perhaps, the best that could be done with our present drain law, and the partially developed condition of our country.

To make this more plain, allow me to introduce a few words regarding the agricultural history of the Huron Peninsula, for drainage and successful agriculture go hand in hand, though remember, it is only surface drainage to which I shall refer. We are not far enough developed to do much in the way of tiling.

Every one knows that, originally, this peninsula was covered with some of the most valuable pine Michigan ever pro-

duced, but unlike the light and almost worthless sands of the central and northern portions of Michigan, it has a loamy soil, inclining to clay, rather than sand, yet not unduly hard. Again, this land is interspersed with the marshes already referred to. These marshes have a mucky surface with clay subsoil, the muck varying from a few inches to several feet in depth, usually, however, not deeper than two or three feet.

It was not until two or three years after the fire of 1871 swept over the country, that lumbering ceased and agriculture really began. For several years it progressed slowly, for the inhabitants of a lumbering country are loth to give up the old pursuit and settle down to agriculture as a business, and not till several years had elapsed, and many of the woodsmen had moved out and given place to settlers who are really farmers, did the business actually change, and the peninsula forsake the aspect of a lumbering country and appear like one given to agriculture. The fire of 1881 followed, and immense tracts of windfall and dead timber were cleared as if by magic, thus offering opportunities to the poor man in search of cheap homes, and good lands, unrivaled only by our western prairies. Immigration rapidly followed, and soon the entire peninsula was settled with sturdy farmers living on small tracts of land of which they were the real owners.

About this time the drain law of 1881 appeared, which, though imperfect, took long strides in advance of the old law which had produced little but litigation and disgust. An impetus was thus added to drainage, for the people were ready to demand it, and many miles of drain were successfully constructed. Other amendments have been made in 1885 and 1889, but all are in the old groove, no practical changes having been made.

This now brings us face to face, ready to talk intelligently about our subject, as we find it today.

As already seen, Sanilac County includes the largest part of the drainage area in question, and I find that the work is nearly all being done in Sanilac County. The Huron County drain commissioner reports on hand 17½ miles of drain, which he hopes to complete this year. The Tuscola County commissioner reports but 8 miles, while the Sanilac County drain commissioner will complete upwards of 50 miles and has 100 miles in process of construction. Huron and Tuscola Counties have each less than 10 miles of drains in the hands of township drain commissioners, while Sanilac County could show more than both, being constructed by township drain commissioners.

One township, Koylton, in Tuscola County, deserves especial mention for the systematic way in which it has taken up its drainage, under its own commissioner. It has constructed, in the last two years, in a first-class manner, about $7\frac{1}{2}$ miles of drain, at the head waters of White Creek, making a ditch 8 feet wide on the bottom near the outlet and 3 feet at the upper end, and averaging about 4 feet in depth, with slope of banks 1.1. Also 6 miles of laterals tributary to this main outlet. These have been done at moderate cost. Sanilac County has completed many as successfully, some being longer, but in no other case has a district been taken up and as thorough work made as in the township mentioned.

The excavating is mostly done with teams and scrapers, or with shovels, the work costing from 8 to $12\frac{1}{2}$ cents per yard. The contracts are all let at public lettings to the lowest bidders at prices given per rod.

We offer a fine field for dredges to operate in, but under our present law the pay is too insecure to induce contractors to bid. In the near future, we hope to take up the head waters of Cass River, and make a good channel for a distance of about 14 miles, and to do the same with Black River and Elk Creek for somewhat shorter distances.

Our actual progress, though considerable, is not what I hoped to be able to report when I promised to write this paper, and really I am not proud of it, when I read of what is being done in some of the drainage districts of Illinois. Even as it is, the work accomplished is valuable, and it would not be exaggerating to say, that the drains are adding value to Sanilac County of not less than $75,000 per year.

METHOD OF STAKING OUT.

The manner of staking out used by most engineers in the peninsula, as well as myself, is essentially the same as described by Prof. Carpenter in his paper on drainage, and already published in our proceedings. But, knowing how eager young men are for details, I will give a few, at the risk of repeating, hoping that in so doing I may help some beginner, and thus partially pay the debt I owe the older members of this Society for similar articles. We stake the center line marking the stakes from the outlet, as the law requires, and set stakes at 2 chains, or 8 rods apart (I would prefer using the 100 foot tape, and staking every 100 feet, but have not yet tried to break over the custom). If the drain commissioner is with me, I appoint him flagman, and direct him to go ahead to a point where it is necessary to change the course, or, if

that is too far, to some point on the already determined line. Then the chainmen are started in, the rear chainman swinging the other into line between himself and the flag. They use three marking pins, two being carried ahead each time, thus leaving one in the ground at the stakes, from which to measure. When the two pins taken ahead are set, the head chainman calls "*stake*," and a man with stake and ax steps into line at the pin, facing the transit man, who gives exact line, and sees that the stake is kept in line till driven. The stake man then proceeds to the next stake point, having procured a stake from another asssistant. In the meantime the rear chainman has dropped his end of the chain, walked ahead to the stake, and handed his two pins to the head chainman, and the work proceeds as before. When an angle point is reached, the head chainman stops, holding the end of the chain at that point, the rear chainman steps forward to the last stake or pin and reads the chain, calling it out to the transit man, who makes the proper record. The transit man also records the magnetic bearing of all courses.

For leveling, stakes are set opposite each center stake, far enough one side to be on the berm of the ditch, between the excavated earth and bank of the ditch. At each of these stakes hubs are driven level with the surface of the ground. The levels are taken on these hubs, and the hubs remain there for the use of the contractor in digging and the commissioner in accepting jobs. This system of staking out, where good work is done, good stakes and good hubs driven, gives the best of satisfaction. The surveyor should not do slouchy work, nor allow any of his men to do it for him. He alone bears the praise or blame, according to the success or failure of his work.

I keep alignment notes in a tabular form much as shown by Beden in his valuable paper on Drainage, already published in our proceedings. The table shows method:—

Angles.	Bearing.	Station.	Chains.	Course.	Remarks.
0	N. 25° W.	0.000	0.000	20.25	"0"=4 chains east, and 15 chains south of n.e. cor. sec. 10, t. 10 n., r. 12 e. Terminus=Etc.
1	N. 40° W.	10 + 0.25	20.25	21.05	
2	N. 30° W.	20 + 1.30	41.30	38.70	
Terminus		40 + 0.00	80.00		
			Proved, 80.00		

I keep topography notes on the right hand page of level book, using for right, the part of the page on the right hand

when standing with face down stream. I keep general width of swamp, as estimated by the eye, or other knowledge, by drawing in an approximate contour of the swamp on each side of a center line and marking estimated widths at abrupt turns and other important points. It is important to show all streams entering the same, their approximate size, and some notes as to character of contiguous high land, character of soil in swamp, and such other facts as naturally suggest themselves. These can form your basis, together with levels, for determining the size of drains. These, too, are copied on the map, not as an infallible guide to the commissioner in assessing, but to aid him in his work.

A profile is carefully made from the level notes to a scale of four chains to an inch, horizontal, and six feet to an inch, vertical. This should show all the facts that can be of use in the construction of the ditch, and give all the data that any other surveyor would need to re-establish the grade at any point.

As our success depends more on the character of the Drain Law than any other one thing, I would like to throw out one suggestion, hoping that it may call out a discussion, though I suppose this is the province of the next paper rather than mine. It seems to me that the great defect in our law, especially for drains of any size, is the manner of working on the credit system, and not raising the money to pay for the work till the drain is located and a tax can be levied on the lands benefited. Thus there are no funds to pay for the work as it progresses, and this makes the work more expensive. But what is worse, non-residents sometimes allow their taxes to be returned, so crippling the treasury as to leave no funds to pay for the work when the orders become due. This causes a sort of uncertainty to hang over the whole business, which very much depreciates the value of orders, and in many cases causes work to be done at speculative prices.

Now if we could have a law similiar to the one in Illinois, or something like the Canadian system, that would allow districts to be formed and bonded for the special improvements, at reasonable rates of interest, pay cash as the work proceeds, and allow the bonds to become due in installments after the benefits have been, at least in part, realized, the now worthless lands would be able to pay their own indebtedness with interest. There is a growing demand for legislation in that line, but just how it should be done I will not attempt to say, for engineers are considered poor law-makers. Last year an attempt was made in the town where I live, and carried so far

as to draft a bill embodying these features, asking for a special act for Sanilac County in view of the large drains we are needing, but it never became more than a "*bill.*"

We live in a wet county abounding in good land (when drained), and are very anxious in this matter. We know that our land is valuable, and can well afford to drain itself if we can only be allowed to go about it in a way that it may be accomplished. And, to say the least, we do not feel grateful when the law-makers in drier sections of the State, not only will not help us in the matter, but will not even allow us to help ourselves.

FRANK F. ROGERS.

NO EXPLANATION NECESSARY.

TOCCOA, GA., February 16, 1890.

F. Hodgman, Climax, Mich.

DEAR SIR:—Prof. Walter S. Wilson, of N. G. A. College, at Dahlonega, Ga., on inquiry by me of him for the best work he knows of on Surveying, sends me your name, as you will see by enclosed letter. Please send me "A Manual of Land Surveying," the book he recommends so highly. He says the price is $2.50; I send check for that amount. If not enough, send the book on and I will remit balance on receipt. Please send the book at once, and oblige,

Yours truly,

LOUIS DAVIS.

DAHLONEGA, GA., February 14, 1890.

DEAR LOUIS:—

Your letter of the 13th inst. was received this morning, and I take pleasure in doing what I can to render you the desired information. The book we used on Surveying was by an English author, Baker, published by McMillan & Co., but the work I am using now as a text-book I consider superior to that one in every particular. It is published by the Engineering Society of Michigan, and is the most satisfactory work, I believe, extant. I purchased it from F. Hodgman, Climax, Mich., who is Secretary of the Society and one of the authors. The title is simply "A Manual of Land Surveying." Col. Price says it is a book that every lawyer should have, as it has the Supreme Court decisions, collected and classified, on every conceivable point that has ever been in dispute before the courts concerning boundaries. Practical suggestions to young surveyors are full, and the theoretical part of the work is in good keeping with the other excellent features.

With many kind wishes for your success, I am,

Your true friend,

WALTER S. WILSON.

To Hon. Louis Davis, Toccoa, Ga.

N. B.—Price $2.50.

The Above Tells its Own Story.

OUR LAWS ON DRAINAGE.

THIS subject may seem anomalous to many members of this Society. There must be others, however, to whom, like myself, it has a practical interest as surveyors.

In our county, and I presume the practice is general, I find it to be the custom of drain commissioners to rely upon the surveyor for advice and assistance in making the necessary papers. As the surveyor's pay for his work depends entirely upon the collection of the drain tax, and this drain tax is based upon the regularity of the proceedings, it may not be amiss to direct your attention to some of the essential points most frequently overlooked.

With a very intricate drain law (I will not say elaborate, for that would at least imply consistency) to work under, and one which no two lawyers will scarcely construe alike, it is theoretically expected that a man who never had to do with law or law forms, aided by defective blanks, will successfully wiggle through the intricacies of the Michigan Drain Law. The court has held that the commissioner cannot pay an attorney out of the drain fund for advice or services, in court, or otherwise;[1] that the forms prepared by the Attorney-General are a sufficient guide; and yet hold drain proceedings fatally defective when they comply with these same forms.

As a prelude, a short history of our drain laws may not be uninteresting or devoid of curiosity. The first Act which I find is in the Territorial Laws of 1819,[2] which authorized the Supervisor "to dig in the highways" and lands adjacent thereto, "such gutters, drains, and ditches therein" as shall be sufficient to carry off the water "with the least disadvantage to the owner of the land," and provided a penalty for filling them up. This Act evidently contemplated that no drainage was necessary except for the benefit of the highway; and the Act of the Legislature authorizing the Supervisor to enter lands was the only right of way then and for many years after, deemed necessary. This Act was embodied in one short section of a dozen lines.

In 1827 the Territory was evidently becoming settled, and something more than highway drainage was needed. In this year it was provided that in case the land was situated so as to be "*conveniently* drained," and the parties could not agree as to how much each should dig, the fence viewers might set

1 Zink *vs* Board of Supervisors, 36 N. W. 73. 2 Volume 1, page 453.

off to each his portion and assess damages for non-performance.

The first drainage Act of the new State was passed in 1839.[1] Any person who deemed it necessary to open a drain through other lands than his own, could have a jury summoned, *ex parte*, who should view the premises of the obstinate party; if, in the judgment of the jury, the damages would be more than the benefits to be derived from the drain, the party applying therefor paid the difference, and in any event, the costs of the proceedings. He could then enter his neighbors' lands "with his servants, teams, carriages, and other necessary implements," and proceed to dig the drain *at his own expense.*

In 1847 an Act[2], supplemental to the preceding, was passed, authorizing the appointment of three County Commissioners "to superintend the draining of such low lands and marshes as do injuriously affect the health of the inhabitants." This Act occupies only two and one-half pages and is but a crude attempt to force unwilling parties to ditch. The Act is historically interesting as first creating the office of drain commissioner, and of authorizing or attempting to levy an assessment for benefits. It contained no provisions for condemning land for right of way, nor were any made until 1861.

In all of the Acts up to 1869, the drain law applied only to lands that could be "*conveniently* drained;" and from the idea of *convenience* probably arose the popular notion that drains could only be laid out in, or following a natural watercourse or swale.

Passing on to the later Acts, I will merely say that our first lengthy drain law was passed in 1869, when the county commissioners were reduced from three to one; that in 1871 the office of township drain commissioner was created, and that our present system was passed in 1885.

My desire was to point out the crudity and ignorant simplicity of our earlier laws. Drain litigation must have been unheard of in those days, and the inhabitants were much more peaceably inclined than at present; for under the later decisions of our courts, not a single drain could have been forced through under those old laws. As a matter of fact, I find but two cases reported prior to 1870; while now, scarcely a term of court passes but what one or more drain cases are disposed of. I shall now call attention to some of those errors, in their order, that should be guarded against.

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1 Session Laws 1839, page 153.

2 Act 104, Session Laws, 1847, page 164.

JURISDICTION OF DRAIN COMMISSIONER.

1 The township commissioner has no jurisdiction to lay a drain extending into, or affecting another township.[1] Nor have township commissioners any jurisdiction to act jointly,[2] as our last legislature made the appointment of a county commissioner mandatory, this is not now likely to occur..

2. The township commissioner has no jurisdiction in or over an old county drain, though the proceedings had by county commissioners were illegal, and the entire drain and lands to be affected thereby, are in one township.[3] It cost one of our commissioners about $400 to find this out. Neither can a drain be re-located or re-established in the line of an old drain illegally laid out.[3 4] Nor can a drain be deepened and widened, in effect, on a petition to clean out.[5]

There yet remain a number of questions as to jurisdiction that are not settled.

1. Under whose jurisdiction is an old drain, wholly within one township, originally illegally laid out by county commissioners, and then later illegally acted upon by township commissioners?

2. Has a commissioner a right to lay a drain across another drain already established?

3. Under a petition to widen and deepen, or clean out, can you also incorporate a prayer to straighten or extend?

These are questions that frequently arise, but as to what answer our court might make to them, I would not hazard a guess.

PETITION.

The petition is the basis of authority to act,[6] and is a much more important paper than commissioners or applicants suppose.

It must show that the signers are freeholders.[7] From the inference of three decisions,[8] it must also state that the proposed work is "necessary for the good of the public health," though this may be waived by acquiescence.

Just how definitely, under the decision, the petition must describe the drain, is uncertain. Under the old drain law, the

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1 Drain Com'r *vs.* Baxter, 57 Mich. 127.
2 Hubbell *vs.* Robertson, 65 Mich. 538.
3 Zabel *vs.* Harshman, 42 N. W. 44.
4 Tomlin *vs.* Newcome, 38 N. W. 315.
5 Harbaugh *vs.* Martin, 30 Mich. 234.
6 Kroop *vs.* Foreman, 13 Mich. 144.
7 Frost *vs.* Leatherman, 55 Mich. 33.
8 Butler *vs.* Supervisor Saginaw County, 26 Mich. 22; Kinne *vs.* Bare, 36 N. W. 672; Gillett *vs.* McLaughlin, 37 N. W. 551.

decisions were conflicting, and really required the petition to be based upon the minutes of survey.

Our court has held, under the law of 1885, that it is sufficient to give the termini and general direction.[1] But the court has also repeatedly held that the petition could not leave it to the commissioner to determine distances or direction.[2] Just where the line lies between these two principles does not yet appear.

Our custom has been, especially where there was likely to be a contest, to survey the drain first, and then incorporate the minutes of survey, in full, in the petition.

THE SURVEY.

The survey of the drain must include a description of the land to be taken as definite as would be necessary for a deed.[3] Not only must the commencement, terminus and courses of the drain be accurately given, but also the points of intersection with the lines of every owner;[3] and the width, depth and grade of the drain. It must furnish the data to be acted on by special commissioners or a jury.[4]

These data should not be left for the map and profile to supply, because they must appear at every stage in the Probate Court, and be found there after the proper papers have been returned to the drain commissioner. These data, which the court has held ought to be present, should not, therefore, be confined to the map and profile.

In my own experience, I have used a form like the following:—

Minutes of survey of Coppernal Drain. Commencing in N. E. ¼ of N. W. ¼ of Sec. 8, T. 5 S. R. 8 E., 30 links west of N., S. ¼ line and 4.50 chains N. of the S. line of said description. Thence running as follows:—

Sec.	Course	Distance in chains.	Grade. in	Cut.	Bench. .....feet.
0				2.16	
1	South	2.50	20	4.51	W. Oak 5
		2.00	to S. line of	N. E. ¼ Sec. by R. Kerr.	8, owned
2	"	2.50	20	4.00	
a	S. 86° E.	1.00			
3	S. 50° E.	1.50	"	3.90	

a = angle.

1 Gillett *vs.* McLaughlin, 37 N. W. 551.
2 Null *vs.* Zierle, 52 Mich. 540.
3 Mathias *vs.* Drain Com'r, 49 Mich. 465.
4 C. M. & C. R. R. *vs.* Sanford, 23 Mich 418.

The map and profile could be duplicated from these data as easily as from the original field notes. While the surveyor may think that the commissioner should be able to take his own data from the map and profile, practically, he will find but very few who are able to do so.

In the survey of a drain that is to be deepened and widened, I would suggest that the minutes of survey also show the present width and depth of the old drain; else how can the exact quantity of additional land to be taken be determined?

ORDER OF DETERMINATION.

The main difficulty with this paper is to get the drain commissioner to set out the minutes of survey in full; he is generally content with describing the center line of the drain only.

PROBATE COURT.

I have now reached the stage which proves fatal to so many drain proceedings, and which renders a drain tax so fallible. Our courts require as great nicety and technicality as in the proceedings of a railroad company to condemn land, and even greater; for while the railroad company condemn the land of but one owner at a time, the drain commissioner must condemn an indefinite number, and a mistake on one piece vitiates the entire proceedings.

As my paper would be much too lengthy to tell all that is required, I shall only touch on those points held necessary by our courts, and either entirely omitted by our drain law or else hinted at so vaguely as to seem unimportant.

1. The drain law makes no provision for citing those parties before the court who have released the right of way. Yet it is necessary, and their lands must be described.[1]

2. The commissioner must show not only that he has not obtained the entire release of right of way, but that the parties in interest refused to give it;[2] and the application may be opposed on the ground that all have not been asked to release.[3]

3. It must not only describe the lands, separately, to be affected by the drain, but must describe the land to be taken for the drain itself as definitely as in a deed.[4] To save repetition hereafter, I will add that this same accuracy of description must appear in the order appointing special commissioners or jury, or venire to summon jury, in the oath to the jury or special commissioners, and in their return or award.[4]

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1 Stackhan *vs.* Drain Com'r, 39 Mich. 168.
2 Morseman *vs.* Ionia City, 32 Mich. 283.
3 C.M.&L.S.R.R. *vs.* Sanford, 23 Mich. 418.
4 Chapman *vs.* Drain Com'r, 49 Mich. 305.

4. The commissioner must show, under oath, what, when, where and upon whom notice of the citation was served;[1] and in computing time, the day of service and of hearing must be excluded.[2]

5. It must appear that the special commissioners or jury had all the papers before them required by statute, and also proof of service of the citation;[3] and the drain commissioner's report is no proof of service.[4]

The foregoing are some of the difficulties that present themselves on every application; and difficulties, too, that do not appear on the face of the drain law.

I might go on indefinitely as to the errors likely to be made in the apportionment, sale and levy of the drain tax; but here it would practically be of little interest. If the proceedings for condemnation are regular, there will be few litigations; for the contestant will save only the interest on his tax for one year, when it will be re-assessed. As a matter of curiosity, I will add that there is no appeal from the commissioner's assessment against the township at large.[5]

In making drain papers it will be found much more convenient to attach all descriptions of land, descriptions of the drain and minutes of the survey, as exhibits. By this method a set of blanks can be made that will apply to every drain, whether long or short, without using more space than is necessary, or of unduly crowding matter together.

All blank forms issued by publishers that I have seen, and many of the forms furnished by the Attorney-General, are defective and misleading. None of the blank petitions contain any reference to the public health. In the published blanks, the space for the description of the drain is much too small and generally lead commissioners and applicants to the conclusion that a very short, general description is sufficient. The same objection applies to all blanks wherein the minutes of survey should appear. The result is that nothing but general descriptions of the drain appear in the proceedings. There is no provision in any of the blanks for bringing parties into court who have released the right of way. The commissioner had better throw away his published blanks entirely, for all proceedings through the condemnation of land.

As I have been calling attention to some of the blind features of the drain law, perhaps a short criticism upon it would

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1 Bennett *vs.* Drain Com'r, 56 Mich. 634.
2 Milton *vs.* Drain Com'r, 40 Mich. 229.
3 Milton *vs.* Drain Com'r, 56 Mich. 634.
4 Lane *vs.* Burnap, 39 Mich. 736.
5 Gillett *vs.* McLaughlin, 37 N. W. 551.

not be out of place. If any of you have had occasion to work with it, you must have felt that it was open to criticism in many places.

If we must have farmers for drain commissioners, and they of all others should be the best qualified to make an assessment of benefits, some provision should be made whereby they can employ counsel. It is folly to expect that an election to office will of itself endow a man with the skill that is to be acquired only by long familiarity with law forms.

It is also a serious question whether or not the township drain law is not an evil. It seems as though one man could do the work for less than fifteen or twenty would, to say nothing of the loss of time, trouble, and mistakes involved in "breaking in" so many.

Again, it is a mistake that the county or township at large are in no way interested in, or responsible for, the drain tax. The result is that public officers take no interest in seeing that the commissioner's proceedings are regular, nor do they look very closely into his accounts. The responsibility of the public for the drain tax ought to be as great as for any other tax; and the public would then provide some means of seeing that it was properly levied and collected.

The powers of the commissioner should be more distinctly defined than at present, as I have before pointed out. The provision for the assessment of benefits should be so modified that it could not be made until after the sale of the drain. Judge Sherwood has expressed grave doubts as to the constitutionality of the present provision.[1]

The provision for vacating or abandoning a drain are a curiosity, and if any one can tell what it means, his acumen would be indeed keen.

The drain law, in fact, is a heterogeneous mass of provisions passed by a legislature who seemed to have very little idea of legal rights or forms, and thought that private property and private rights could be invaded without any other process than the mere *fiat* of a session law.

Its practical workings, where lands are owned by non-residents, is about the same as the old law of 1839. The unfortunate resident who is forced to have a drain, "can enter with his servants, teams, carriages and other necessary implements," and proceed to dig the drain at his own expense; for a drain tax, assessed against non-resident land, is very rarely paid and could be still more rarely enforced.

WILLIS BALDWIN.

1 Kinne *vs.* Bare, N. W.

IRRIGATION IN COLORADO.

IRRIGATION is not a new question to the human race, but to the English speaking people and their ancestors, living in countries whose natural rainfall is sufficient to the practice of a successful agriculture, irrigation has not been a necessity, and we, as a people, now meet this problem of irrigation without acquired experience.

Arid lands are not the only lands benefited by irrigation. In countries having an abundant rainfall but suffering an occasional drouth in heat of summer, irrigation furnishes water to the thirsty crops, and even in the most favorable years increases the products of the farm.

That irrigation is beneficial in countries of abundant rainfall, witness the valley of the Po, the garden of Europe. That valley has a rainfall greater than that of Michigan, yet so apparent are the benefits of irrigation, that the irrigated area has doubled in the last thirty years.

Agriculture cannot generally be successfully followed in regions where the rainfall is less than twenty inches. In the United States the line of twenty inches rainfall passes south through central Dakota, western Nebraska, Kansas and Texas. Except for a little area on the Pacific coast, all the region west of the above named line has a rainfall so small as to make ordinary agriculture precarious. The eastern limit of this arid area will be put at 98° by the United States Senate committee on irrigation, making this arid area include about one-third part of the United States—and this by no means the least fertile part, as some of the finest crops in the world are raised here in the heart of the American desert.

EXTENT OF IRRIGATION IN COLORADO.

There are now some 1100 canals in Colorado. The primary canals, meaning by this all those which take water from the river, irrespective of size, measure over 6000 miles. The secondary canals it is impossible to estimate, but as these include all the branches of the primary canals, some of which are forty feet wide on the bottom, it is evident the mileage is very great.

In the short time since Colorado began to irrigate, some 4550 square miles or 3,000,000 acres have been brought "under ditch;" of this amount, taking the State as a whole, probably not far from one-third, or one million acres, is actually irrigated. Considering the fact that Colorado's irrigation development dates back only fifteen years, this is a creditable illus-

tration of the activity of the western people, and the way they are taking hold of the problem of irrigation. In France there were in 1887 only 400,000 acres irrigated. In the valley of the Po there were, in 1882, after six hundred years development, 3,000,000 acres irrigated.

Some canals date back to 1859, more to 1864, but until the Greeley colony settled on the plains in 1871, it was not generally believed that the mesa or uplands were worth anything. There had been a few ditches successfully watering the highlands as long ago as 1864, but these cases were not generally known. The first ditches were small. One ten feet wide on the bottom was an exception. The large ones are all of recent date, most of them having been built since 1880. Some of these have cost hundreds of thousands of dollars, and water thousands of acres of land, and are forty, fifty, or a hundred miles in length.

At no time has there been more activity in ditch construction than at present. The valleys of the Platte and its tributaries from Denver to the mouth of the Cache a la Poudre were first developed, and are the oldest agricultural regions of the State. As mentioned before, the town of Greeley lies in this region. The lower Platte has developed little on account of shortage of water. To supply the area already developed, and to furnish water to the lands rapidly being brought under cultivation, reservoirs for the storage of water are being built in the mountains and on the plains by individuals and by companies. These reservoirs vary in size from 300 acres to small ones intended for a single farm. Reservoirs are destined to play an important part in the future of the irrigation economy of the whole West.

The first problem of the irrigation engineer ought to be that of the water supply. By the laws of the arid region, the first ditches have the prior right, hence any new ditch must get its supply after the rest are satisfied. Some ditches costing hundreds of thousands of dollars have apparently been built without much regard to the supply of water.

CANALS.

These are generally built through lands in advance of all settlement. The projector often buys of the State large blocks of land which, when watered, become very valuable. Though most of the canals are of this character, settlers sometimes, in self-defense, combine to take out a canal for new lands, starting the head above that of the first or old canal, or

they may run a new ditch parallel to the one whose charges they consider exorbitant.

HEADS.

Where the lands are chosen with a view to bringing under cultivation by means of water, it is necessary to first find a suitable location for the head works. A favorable site is all important, so that a headgate and dam may be built without too great expense and with little risk of washouts or of being separated from the stream by sand deposits. Account must also be made of the effect the site will have upon the route below; whether it leads to a favorable course above the bluffs to the objective table land or not. The selection of a site is less important on streams with a rapid fall and firm bottom, than in sandy ones, like the Platte or the Arkansas.

The site selected, the line is then run from the site of the headgate and with the fall which the engineer desires to give, which will vary according to the size of the ditch and the character of the soil, he should not lose sight of the fact that the ditch is to be maintained and that the cost of maintenance depends much upon his judgment in selecting a route.

Sand, extensive fields of which line both the Arkansas and the Platte Rivers, it is always desirable to avoid, as it drifts into the ditches in such quantities as to cause a heavy yearly expense for cleaning, and the loss by percolation or seepage of water is very great.

Flumes and artificial embankments are also to be avoided, if possible, as the former are a constant source of expense in money, water and care, and the latter are subject to the burrowing of moles. The flumes and embankments cause more anxiety to every ditch manager than all the rest of the canal together. If either flume or embankment must be had, then it should be built with proper care, for a break in the busy season means the loss of thousand of dollars to those taking water, possibly the loss of the entire season's work.

Floods are to be provided for, if possible. The plains shed rain like a roof and one learns to respect every insignificant "draw." As an instance I may mention the flume across Horse Creek, on the Henry canal, as shown in one of the smallest photographs accompanying this paper. When I visited it in April there was no water above the sand. The flume, on pile bents 16 feet apart, was high enough in most places to drive a carriage under, yet a sudden storm on the plains in June made this stream a torrent, broke the piles like pipe-stems and wrecked the flume.

GRADE.

The fall needs to be sufficient to give a current with a velocity which will prevent the growth of aquatic plants tending to choke the ditch, but not so great as to seriously scour the channel or be unmanageable in high water. The velocity desired is from two to four feet per second, depending upon the size as well as the grade of the ditch; greater grades may be used in smaller ditches than in large ones. The following table gives the grades of most of the large canals. The tendency, at present, seems to be to lessen these grades somewhat.

Name of Canal.	Grade.	Carrying Capacity.	Width, Feet.	Length, Miles.
Larimer and Weld	2.37	720	30-18	64
High Line Canal	1.76	1184	40	85
Rio Grande	2.45	.....	.....	.....
Citizens	3.0 to 0.5	.....	40	.....
Uncompahgre	3.38	725	.....	32
Henry	2.11, 1.58	.....	30	112
Grand River	1.82	.....	.....	.....
Fort Morgan	2.6, 1.57	340	30	28
Springdale	3.6	115	20	13
Pawnee	1.67	415	35	30
Schneider	3.2	.....	14	.....
Platte and Beaver	2.56, 2	313	30	25
Platte and Beaver Supply	2.11	.....	26	.....
Weldon Valley	2.5	300	20	16
Kiowa and Bijou	1.5	.....	40	50
Prairie	2.7	.....	20	26
Lariat	10	.....	20	4
North Poudre	2.11	.....	.....	.....
San Luis	2.64	.....	34	50
Empire	1.67	.....	60	35
Bessemer	1.25 to 3	.....	24	20+
Dolores, No. 2	2.56	.....	25	6
Amity	1.06 2.11	.....	35	.....

CROSS SECTION.

The cross section of a ditch is trapezoidal, wide in proportion to depth. On account of loss by evaporation, it would seem better practice to build the canals narrower and deeper than is the usual practice. The side slopes in natural earth are 1 or 1½ to 1; occasionally, as in the Del Norte and the Citizen's canal, 2 or 3 to 1. In artificial embankments the slope is 1½ or 2 to 1. The excavated earth is generally put

into an embankment on the lower side of the canal. The top is brought to grade with the intention of making the embankment increase the carrying capacity of the ditch. Practice varies in the use of a berm. When used, four or five feet is sufficient. The movement of earth is done with "slussers," or with wheeled scrapers, at a prevailing cost of 9 or 10 cents per cubic yard.

In several localities ditching machines are used for constructing the laterals. The Monte Vista canal company, as well as that of the Grand River, use a steam dredge for cleaning and extending the ditches. These were adapted to the work and were introduced by W. H. Graves, C. E., the engineer of these enterprises. These are said to excavate at a cost of 3 cents per cubic yard.

HEAD WORKS.

These consist of the dam, waste gate, sand chute, and headgates. The dams are as various as their conditions. They do not generally act as a dam proper, but as a dam for diversion of water. On rocky bottoms it often consists of a few rows of loose boulders sometimes filled in with brush. In the sandy streams of the plains they are all deflecting dams only. In many cases they are simply sand embankments, thrown up with a scraper, running obliquely up the stream, so as to have no pressure to withstand. Every flood washes them out, but they are easily rebuilt. One photograph shows the dam of the Platte and Beaver canal near Fort Morgan, which is the only permanent structure worthy the name on the lower Platte. It consists of a double row of piles eight feet apart, driven at least one or two feet into bed rock, which is 8 to 14 feet below the surface. Each row of piles is sheet piled, each plank being driven to bed rock. The upper piles are $1\frac{1}{2}$ feet above low water. The space between the piles was excavated for three feet and filled with one foot of brush, and two of stone. The dam is 832 feet long and the headgate cost $12,000.

The Platte, it may be said, is a very peculiar river, dry at one point and a little way below a lively stream of water. The sands are generally saturated with water. A dam like that of the Platte and Beaver is intended to intercept the underground flow and bring it into the canal. In the mountains some solid dams are built, as the photograph of the one on the Big Thompson shows.

SAND CHUTES.

In many places the sand is carried with the current. It is not in suspension, but the current rolls it along the river bottom, where it soon fills the headgates and upper portions of the canal. Many preventive devices are tried, but none, so far, are completely successful. The one that appears to do best work, is to keep a flash board below the headgates proper. This causes the sand to fall in front of the gates, and when the deposit has acquired a certain depth it is drawn out by opening the waste gates.

THE WASTE GATES.

The waste gates, if any, are generally supplied with flash boards. Several photographs show them in connection with the dam.

HEADGATES.

The headgate forms, in general, the most important and expensive structure of the ditch. It is built always of wood, though the time is not far distant when we shall follow the example of Italy and build of the stone which is so abundant everywhere. The headgate consists of piles, surmounted by heavy timber, securely braced to withstand the pressure of the water. Aprons should be used in all such structures, though sheet piling is frequently found instead. The gates vary from 3 to 6 feet, clear opening. A good type is that of the Del Norte canal in the large photograph.

FLUMES.

Examples of flumes in the High Line canal in Platte Canyon, 2640 feet long and 28 feet wide, 7 feet deep, grade 5.28 feet to the mile. Also one of similar construction on the same canal over Plum Creek. The latter is some 1800 feet long. It consists of bents of eight piles each 18 feet apart, the piles 6 feet, 3 inches apart. Mudsills 12x12 inches and 48 feet long made of three pieces. The posts are 10x10 inches, mortised into sill and cap. The piles were mortised into the sills, but now the practice is to drift bolt entirely, that costing less and the pile lasting longer. Other views show the excellent Fort Morgan flume nearly half a mile long, the flume near Lamar, one on the Henry canal, etc.

A blue print of the Del Norte, now called the Rio Grande canal system, is inclosed as an illustration of a canal system. This is probably the largest canal in the United States. Starting near the town of Del Norte, at the point where the

Rio Grande enters the San Luis valley, it skirts the foot hills and passes out into the valley. Its course is nearly at right angles to the river, as the river is in the highest part of the valley. It secures its supply of water by damming a branch of the Rio Grande and turning the water down its headgates. A screen made of piles and some distance in front of the headgate, keeps out all floating timber.

The headgate consists of ten gates raised by a screw worked by a wrench. The canal at the head is 65 feet on the bottom and carries $5\frac{1}{2}$ feet of water. The side slopes are 3 to 1, making the width at the water line 98 feet. Four miles from the head it is bifurcated, the large branch being 42, the small one 38 feet wide. Each of these branches gives rise to various laterals, which have been built by the company. These are generally 10 or more feet wide. The length of the main canal is about 50 miles, of the laterals 150 miles. A study of the map will show the unusual character of the country, which is very uniform and slopes from the river. The ditches follow the section lines entirely. All the region between the two branches may be watered from either branch. As an illustration of the evenness of the country, it may be mentioned that one canal runs 26 miles on a section line.

Many other points regarding irrigation and construction it is desirable to mention but lack of time and space prevents. Had it been possible to have had them drawn in time, detailed plans now in my note book of dams, headgates and flumes would have been sent you. L. G. CARPENTER.

Prof. Greene.—"Two or three matters occurred to me as the paper was being read. There is no doubt that the farmers of the West wish the matters of irrigation should go as far as possible, but I think that a great many of these constructions must be of a very temporary nature. It seems to me that though very satisfactory now, there will be in the future considerable expense for repairs. Of course it is to be said that if they were built of stone the work could not have been carried to so great an extent, and there is no doubt structures in the future will be more permanently constructed.

"Another point is in reference to the right of riparian owners. It would seem that where irrigation laws are in force it may happen that one party may have the right to take all of the water from a stream and appropriate it to his own use. That is quite different from the rights of riparian owners in this State and those living near the head waters of a stream would have the best chance."

Mr. Forster.—"A good deal of this is hinged in the mining laws."

Mr. Hodgman.—"It might seem at first thought that the question of irrigation is of little interest to us in Michigan, but to me it has an interest in two ways. First, the great irrigation works of the West are already furnishing employment to some of the members of our society, and are opening out a wide field for the employment of engineelrs in the future Second, I have great interest in whatever will tend to make more prosperous the people in our own State, and I am very confident that the conditions now exist which will make it profitable to irrigate a very considerable amount of our lands right here in Michigan. We are subject to periodical drouths by which our crops are greatly lessened and many times ruined entirely. There is a great deal of land in Michigan so situated with reference to the streams, that it can be easily and cheaply irrigated. Take, for instance, the land in the valley of the Kalamazoo in my own county. There is a tract of land from half a mile to a mile or more wide, extending for from 25 to 30 miles, in that county, which could readily take the water from the river for irrigating purposes. In addition there are numerous tributaries, small spring streams, which never fail, emptying into the river all along the valley. These streams are admirably situated for purposes of irrigation, and I believe that in many cases the small expense required to turn them so as to utilize the water would, in some of our dry seasons, be repaid by a single crop. I had opportunity a few years since to become quite familiar with such small irrigation works as would be required in the case I have mentioned, and it may be of interest to the members of the society to know a little more of the details of how the work is done. The parties wishing to irrigate their lands go up stream to a point sufficiently high to get the necessary fall. How far that will be, depends on the fall in the stream and the hight of the valley above it. Having found this point, a ditch is started down stream and gradually leading away from the main stream. The ditch follows very nearly on the level contour line, only dropping enough below it to give the necessary flow to the water. For a small ditch which is only expected to water two or three small farms, the line is marked out by stakes stuck along at short irregular distances, and then when the ground admits of it, a back furrow or ridge is turned up with the plow. Then on the uphill side of the back furrow the ditch is cleared out and opened with the spade or shovel; the dirt which is taken out being used to build up the banks. The

water in the ditch is above the surface of the land adjoining, held there by the banks thrown up. On the downhill side of the ditch is the furrow made by the plow in turning up the back furrow. This is cleaned out to be used as a channel for the water to run in when required. The land to be irrigated, after being sown or planted, has little furrows made all over it running up and down the slope from the margin of the ditch. These are made by a tool made something like a corn marker, with the teeth about a foot apart. It is made from a small log from 3 to 10 feet long, according as the surface is rough or not, with pegs driven in to make the furrows. The fields after being furrowed, resemble a field just drilled into wheat. When the land is to be watered, two little dams made of a few shovels of dirt are thrown across the plow furrow, which parallels the ditch, at a distance of 2 to 10 rods apart. Then an opening is made in the bank of the ditch; the furrow between the dams fills with water and overflows, the water running down the little furrows or drill marks. A man keeps along with the water as it flows and removes lumps of dirt or any other obstructions which may prevent the water from finding its way down any of the little furrows. When the ground is sufficiently watered, the opening in the ditch is closed and another strip watered in the same way until all is done. I have crossed fields in Utah that had been irrigated, where I would sink nearly to my knees in the mud at every step. In many cases these irrigating ditches furnish the farmer all the water he has to use, and the man and his wife, his horse and his pig all drink from the same ditch. I had sometimes to do the same or go without water."

Mr. June.—"This matter of irrigation in Michigan comes home to us in Osceola county, where we have a good deal of land that might be irrigated that is nearly worthless without it. One man irrigated a patch of potatoes last year and got a big crop, when all the rest were nearly a failure. Sylvan township is somewhat flat and it is the only township that has done anything with drainage, let alone irrigation. I should say that about five miles of ditch have been put in for the purpose of draining land rather than wetting it. The water of that ditch could all be used profitably, and I see that this may amount to a good deal here, as well as in the West."

Prof. Greene.—"It is suggested that irrigation might be a good thing for some parts of Michigan.

"You cannot irrigate a country unless you have water. And you cannot get water unless you get rainfall, and if the rainfall becomes so little that crops will not grow that is the

end of it. In the West the water comes from the accumulation of the snow on the mountains, enough to carry them through the summer, and yet sometimes there is not enough to satisfy the country. We have seen statements in regard to the subsidence of the level of the great lakes, that vessels carrying a certain draught could not pass. Attention has also been called to the fact that the smaller lakes have been going down. I have been interested somewhat with regard to my water supply, so I have collected some facts which I have put on paper in the form of a diagram. Some notes as to rainfall are taken by the State Board of Health.

		At Ann Arbor.
In 1877	35.25	
In 1878	38.06	
In 1879	36.35	
In 1880	41.88	
In 1881	43.21	40.36
In 1882	37.25	36.22
In 1883	40.91	35.27
In 1884	37.02	.....
In 1885	35.82	35.14
In 1886	32.16	20.6
In 1887	.....	28.65
In 1888	.....	26.52
In 1889	.....	23.34

"Ann Arbor lies on a gravel soil which rapidly absorbs water. Trees put out their leaves and grow, and in the latter part of the summer they suffer from drouth. But all this don't bring the rainfall.

"If that continued through a series of years, irrigation would do no good, for you would have no rainfall. If we could have our rainfall in the summer instead of in the winter, as we have it now, something might be accomplished.

"You can't supply a place with water where you don't have rainfall enough to supply the demand. I think that the precipitation will increase, and I expect to get back to the time when we will have plenty of water."

Mr. Forster.—"It seems to be on the increase."

Mr. Hodgman.—"I did not wish to be understood that all parts of Michigan can be irrigated, or that it would pay to irrigate everywhere if it could be done. But I am very sure there are many very considerable tracts of land in the State that can be profitably irrigated from spring streams that are no more uncertain in their supply of water than are the streams of the West."

Prof. Carpenter.—"In connection with Prof. Greene's remarks, I would say that I have just come from a State where the condition has been the reverse of what they have here. In New York they have had 72 inches of rain since last May. While our farmers have suffered from drouth, they have suffered from wet. In places the streams have left their beds and run across fields and roads, cutting channels and doing great damage."

Mr. Hodgman.—"That is what I would call running irrigation into the ground."

Prof. Carpenter.—"We have three wells at the college and during the dry time it was thought they would not hold out; but they have. This indicates a head somewhere not affected by the drouth."

Mr. Wells.—"In Wexford county is a tract known as Briar Hills which lies about 1200 feet above Lake Michigan. Below them are agricultural lands lying about 500 feet above the lake, and still further west another tract of about 200 feet elevation. In the Briar Hills many spring brooks take their rise and have cut deep channels in their way to the lake. A year ago this summer, when it was a very dry season, I noticed that the farmers' crops were parching in the sun and these streams running as full as ever. If the water had been utilized it would have saved the crops for some parts of Michigan."

. . . THE . . .

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AN INDIAN LEGEND.

THIS legend was recited by David Shapanagon, an Indian living at Grayling, Michigan. He speaks broken English, has learned but very few words, and is therefore obliged to make the same word do duty for several different meanings. He is about 70 years old, and has considerable dramatic power. He says that the legend was taught to him when he was a child; that he has recited it many times before large audiences of Indians, and sometimes has received a pony as prize for the best story. He believes it to be true. The writer heard of the legend through Mr. A. B. Valentine, formerly surveyor of Montmorency County, Michigan. Mr. Valentine speaks Chippewa, and had hunted with Shapanagon, and had heard him recite the legend. Mr. Valentine told fragments of it to the writer and referred him to Shapanagon. The writer visited Shapanagon about four years ago, and heard the legend once. Its recital occupied about two hours. It has been written from memory. The salient points are all preserved, but the details are very deficient; this is especially the case in the description of the storming of the Saugee village and the massacre of the inhabitants; here the recital was especially animated. The orator was very dramatic and graceful, but so much depended upon the action and pantomime that all the writer can remember seems very meager. When he says his "*grandfather*" settled in the country of the Saugees, he probably means his ancestors. When he uses the term "*five hundred years*," he probably means a long time; also, when he speaks of "*five thousand men*," he means a great many, a host, a multitude. When he says that "*the chief spoke an hour*," he means that he made a long speech. It is probable that he used these words, because he knew of no other in English, but if he had spoken in his own language he would have given different shades of meaning.

Five hundred years ago the Chippewa Indians lived at the Straits of Mackinac. They had all the land on the other side of the Straits up to Lake Superior; on this side their land came to the Au Sable and Manistee Rivers—(in one place these two rivers came close together, not a mile apart; this narrow place was the boundary). Their largest city, where their head chief lived, was at the Straits of Mackinac. The Saugee Indians lived on the south side of the river, around Saginaw Bay. Saginaw means Sow-gee-naw, or the country of the Saugees. Their largest city, where the head chief lived, was near where Sebawaing is now; they had another smaller city where the three rivers meet at Midland. If any of the Sau-

gees went hunting on the north side of the Sable or Manistee Rivers, then the Chippewas could kill them and scalp them, and there would be no war. If the Chippewas went hunting on the south side of these rivers, and the Saugees could catch them, then they could kill them and there would be no war. One autumn, after the hunting was over, the Chippewas came back to Mackinac to stay all winter. One family did not come, so their relations told the Chippewa chief. He asked all the men that had been out hunting, "Have you seen this family?"

One man said, "Yes."

The chief said, "Where were they?"

The man said, "They were in a camp close by the Sable River, but on their own side."

The chief said, "When did you see them?"

The man said, "Five days before I started to come here."

Then the chief said, "I want you to take twenty men, all swift, and go and find out what has become of this family. If the man is hurt, or his family is hurt, then you help them come here. I make you chief of the twenty men."

Then this man got twenty other men, all swift. They went through the woods, because it was so near winter that they thought there would be wind and rain on the lake, but there was no wind or rain, so they went fast and came to the place where the man's camp had been. The man and his family were gone. He had one kettle made of clay and one stone ax; these were gone too. There was a heap of ashes where his camp fire had been. Then the chief said to one man, "You stay here and cook." He said to the other men, "Stand in a ring around the camp, with your backs in and your faces out; then every man go in the way he is looking. Look on the ground, logs, trees, bushes, in the water, everywhere, to find this family. When you get farther apart, go to the right hand until you meet the man on that side, then go to the left hand until you meet the man on that side, then go back to your own place and go on a little farther, and do so again so that you will look under every tree in the woods. When it gets dark, lie down right where you are, so as to begin hunting in the morning, for we must find this family before the snow covers up their tracks."

That night it rained very hard, because it had not rained any before; all the leaves hung straight down, and the water ran down both sides. In the morning the cook was pretty wet; he walked around, pretty soon he saw that the ashes had sunk down in the middle. What was that! That

must mean something! He went out into the woods and called. By and by a man answered him and said, "What do you want?" Then the cook man said, "I want all the men to come back, I have found something." So one went to the right and told that man, and the other went to the left and told that man, and they told the next man, and so all of them came back to the camp. Then the chief man asked the cook man what he wanted. He said, "Have all the men stand around the ashes, this time with their faces in." Then he showed the chief where the rain had made the ashes sink down in the middle. The chief said, "What is this?" All the men said, "I don't know." The chief told the men to dig. They found that the ground had been dug up before. Pretty soon they found a man's hand; they pulled him out. Next they found the woman, and in the bottom the two children; all of them had been tomahawked and scalped. The chief said, "All of you look and remember what you see, so that we can tell when we get home." Then they got all of the bodies straight, and put clean birch bark around them, and dug a grave for them, and after it was filled up they put four sticks at the corners. Then they started home. The rain turned to snow, but all the men were swift and could go a long time without eating, so they got home. Then all the people asked them, "What have you found?" The men said, "We are hungry." The head chief said, "Give them something to eat." After they had eaten all the people asked them again, "What have you found?" And the men said, "We will smoke." Then the head chief said, "Bring them pipes and tobacco." After they had smoked, the head chief said, "Sit down in a ring, and let your chief man tell us what you have found." So they sat down in a ring, just behind them the men, and farther back the women and children. Then the chief man told the head chief all that they had found, and the other men said it was true. Then the women began to cry. The young men said, "The Saugees did it, we will go and kill them," and they waved their tomahawks and jumped up and down and patted their hands on their mouths and whooped. After a long time the head chief said, "Listen, I don't know who killed this family. It may have been the Algonquins; it may have been the Winnebagos; maybe it was the Saugees; I don't know, we will go and find out." So the young men waited.

* * * * * * * * * * * *

When the spring came, the Chippewa chief told five thousand of his men to get ready and go with him to see if the Sau-

gees killed that family. So they brought their canoes and put two side by side, and covered them over with bark. Then in the middle they had a pole about ten feet high; on the top of this pole they placed a bunch of feathers—some red and some black. There were more than five hundred such canoes, and the chief had the largest one. Some men would sit in the canoes and paddle; some more would stand up on the bark decks and dance. They had feathers in their heads and paint on their faces, and did not wear any clothes except around their waists. All of them had tomahawks and bows and arrows. They did not start until there was no wind, then all of the canoes kept together, and the men jumped and danced and whooped all the time. When the wind blew they went on shore and waited until it stopped. So it took a long time, three weeks, to get to the Saugee city. When they came in sight, a Saugee man saw them and went to the Saugee chief and told him that the lake was getting black. Then the Saugee chief went to the bank of the lake; he heard the whooping and saw the men dancing on the bark decks of the canoes. He told all the Saugee men to come to the bank of the lake, for the Chippewas were coming and wanted something. So when the Chippewa boats got near the shore all the Saugee men stood on the bank. Then the Saugee chief said:—

"What do you want?"

The Chippewa chief said: "We want to come on shore and talk with you."

Then the Saugee chief told the Chippewa chief and his men to land. He made a line that was a little way back in the woods and parallel to the shore. He told the Chippewa chief that his men could stay between that line and the water. So the Chippewas came on shore and drew their canoes up on the sand. Then the Chippewa chief said to the Saugee chief: "We want to eat." So the Saugee chief had plenty of fish and venison and corn brought to the Chippewas, and they ate all they wanted. Then the Chippewa chief said, "Let us smoke." So all of the Saugees sat down on one side of the line and the Chippewas on the other side facing them. The two chiefs were at the upper end of the line facing each other; next to them were the older men; then came the younger men, so that the youngest Chippewa and the youngest Saugee sat facing each other at the lower end of the line. Then the Saugee chief had the women bring him a hard, dry piece of elm wood, and a round hickory stick like a cane. One end was rounded off so that its point was smooth and hard. In the block of elm wood there was a small hole like a cup. The

chiefs stood the hickory stick in this hole; then they took some punk that they got from a rotten log and picked it up fine and put it in the hole around the end of the stick. Then the chiefs whirled the stick by rubbing it between their hands, so. There was a stone on top of the stick to hold it down. Pretty soon the lower end of the stick began to smoke; then the punk caught on fire. This was a good fire because it was new. No one had a chance to put anything bad in it, or say any devil words when they were making it. Then the chiefs lighted a large pipe, the Chippewa chief took one mouthful of smoke and handed the pipe to the Saugee chief; he took a mouthful and handed it back to a Chippewa man, and so the pipe went backwards and forwards down to the end of the line. Then every man took his own pipe and smoked and laughed and talked about common things. Sometimes a Chippewa would tell a story and the Saugee who sat opposite to him would laugh; then the Saugee would tell a story and may be the Chippewa would laugh, but the Chippewa said nothing about the family that were murdered. After one hour, the Chippewa chief stood up and said: "We came to talk to you about something." Then he told the Saugee chief all about the family that had been killed and scalped, and said: "We have come to ask you if any of your men did this." Then the Saugee chief said: "I feel badly. I do not know who killed this family. Maybe there are some bad Saugees who know about this; I will go and see." So the Saugee chief called all his people together and asked them if anyone knew who killed this family. Some of them got afraid and told who did it. There were six of the murderers; they thought they had buried the bodies so that no one would ever find them, but they showed the scalps to some of the Saugees, and these men told the chief. So the Saugee chief came back and said to the Chippewa chief: "We have found the men that killed this family. Now, what do you want?" The Chippewa chief said, "Give them to us." So the Saugee chief had these six men tied so they could not move; then he had them laid on the ground before the Chippewa chief. These men felt pretty badly, but they did not say anything. The Chippewas tied them to three stakes, two on each stake, back to back. Then the relations of the murdered family came first with their flint knives, and each cut off a piece of ear or nose or cheek. Then all the other Chippewa men came and each cut off a piece. Finally when the Saugee murderers were almost dead, the Chippewa chief came and scalped them and had the scalps for himself. Then the Chippewas piled wood around the dead bodies as they hung on the

stakes, and burned them up. All the time the Saugees stood back a little way and looked on. They felt pretty badly but were afraid to do anything, because there were five thousand of the Chippewas, and each man had his tomahawk. The relations of the men that were burned up saw it too, and they felt the worst of anyone. They were afraid to say anything out loud, but said low to each other: "When we get a chance we will kill some Chippewas and scalp them." Then the Chippewa chief said to the Saugee chief: "I want to say something more to you. You have seen what we have done, and know what kind of men we are. If you want to fight with us next year, we will fight with you then; if you want to fight with us next month, we will fight with you then; if you want to fight with us now, *lift up your tomahawk*," but the Saugee chief let his tomahawk hang down. Then the Chippewa chief said: "If you don't want to fight with us, we will get in our canoes and go home. We will hunt on the north side of the rivers and you may hunt on the south side as we did before. We will bury the tomahawk, so, with the handle sticking up out of the ground. Then, if your people kill any more of our people, we can *take it up quickly*. We will go back this one time. If we ever come again, *we will stay*." So the Chippewas got in their canoes and went home. All that year they hunted and fished and nobody was killed.

* * * * * * * * * * * *

The next year a family of Chippewas had their camp on the north bank of the Sable River. A Saugee saw it, who was a relation of the six Saugees who had been burned. He told some more of his relations; they talked together, but did not let the Saugee chief hear them. They said: "We will kill this family of Chippewas, and no one will know who did it." So they killed them and scalped them and hid the bodies in a swamp. When the time came for the family to come home and they did not, the Chippewa chief sent men as before to see what was the matter. After a long hunt they found the bodies and came back and told all the people about it. Then the young men said, "The Saugees did this, let us go now and kill them and scalp them." The Chippewa chief said: "Wait until we are ready, so that we can kill them all." But the young men said, "We are ready now, if the chief is afraid to go with us, he can stay, and we will have another chief." Then the chief called all the men together, and he stood up and talked one hour to them. He said: "We must kill all of the Saugees. All of our men must go. It will take all summer. We must leave

something for our women and children to eat while we are gone. We want some dried fish and venison to take with us. We want more canoes; we want more tomahawks and arrows. It will take one year to get these things. If you go now, there will be ice in the water and snow on the ground before you get there. If you have had nothing to eat on the road you will be weak, and the Saugees will be stronger than you are. I am not afraid. You saw me when we went there before, and took the six men and burned them. You heard what I said to the Saugee chief. If any young man thinks he is braver than I, let him stand up and speak." The young men were ashamed and did not say anything. A good many of the old men stood up and spoke, and at last all thought the chief's way was best. So the chief told all the hunters to dry and keep half of all the venison and fish that they got the next year. He told the men that made canoes, and the men that made arrows and tomahawks, to make twice as many as before, and save one-half; and so about everything that was made. Every Chippewa, man and woman, had to do twice as much that year as ever before. The chief told all the men and women and children not to tell any other Indians what they were doing. So if a Winnebago came to the Chippewas and asked: "What do you make so many canoes for?" the Chippewas would say: "Oh, maybe next year we will go to Lake Superior and fish." So for one year the Chippewas got ready and the Saugees thought that nothing would happen to them. Finally, when all was ready, the Chippewa chief took five thousand men and started. One-half of them went in canoes, and one-half went on foot through the woods. Those that went in canoes were going to Sebawaing, and those that went through the woods were going to Midland. The head chief went in a canoe. He made another man chief of the men that went on foot. He told this chief to get to Midland in just twenty days and begin killing the Saugees at day-light in the morning, He told this chief to have some swift runners go ahead of his men, and if there were any hunters camped in the woods, to kill them, so that they would not run home and tell the Saugees that the Chippewas were coming. He had two canoes, with swift paddlers, go ahead of his other canoes, so as to catch and kill any fishermen, and not let them get away and tell the Saugees that the Chippewas were coming. The men in the canoes went slowly, so as to get to Sebawaing just the same morning that the other men got to Midland. When the Chippewas got to Sebawaing, they found the Saugees all asleep; they got all around the village, and at daylight they all whooped and ran

in. The Saugees did not know what to do. The Chippewas killed them—men, women and children. The Chippewas set fire to the houses. The dogs barked and the Chippewas killed them too. Some of the Saugee men got away and ran towards Midland; half way there they met other men running away from Midland; then all ran towards where Port Huron is now. The Chippewas followed them; if a Saugee man got tired the Chippewas killed him and scalped him. About one hundred Saugee men got to Port Huron and crossed the river on logs or swam. The Chippewas did not follow them any farther and never heard of them again. All of the Saugee women and children were killed, and their dogs and pigs and ponies. When the Chippewas got back to Sebawaing the chief called them all together and said: "This is a good land and there is no one alive in it; if any of you want to stay here you can." So a good many of them stayed, and among them was my grandfather. He and his children always lived there afterwards.

E. S. WHEELER.

A MANUAL OF LAND SURVEYING.

Owosso, MICH., Dec. 16, 1889.

MR. HODGMAN, *Sec. Mich. Eng. Society.*

DEAR SIR:—Enclosed please find draft for your bill short bank exchange. The Manual of Land Surveying received from you some time since, is a splendid book, worth twice its price. Yours truly,

H. C. MAIN.

Shiawassee County Surveyor.

F. HODGMAN, Climax, Mich.

TRUE EXTERIOR BOUNDARY OF THE TOWNSHIP.

A CONTRIBUTOR to our exchange from the Illinois Society of Engineers and Surveyors, for 1888, advances ideas that I can not endorse.

After a vast expenditure of ink, and some erudition, he comes to the conclusion "*that the boundary, as modified by subdivisional survey lines and corners, is to be regarded as the true boundary line of the township.*"

This interpretation would ignore the following facts in relation to this question:—

1. The principle universally recognized in all the public surveys, that consecutive corners—except in the case of meanders—are to be joined by right lines.

2. That all subdivisional lines of any legal division, are controlled and determined by the boundary lines of such division.

3. That the closing of subdivisional lines at points not in the boundary of the legal division thus subdivided, is anomalous to the fixing of the interior corners; and therefore not subject to the same law.

4. That the closing corner is always described and returned by the deputy-surveyor as being on the boundary line.

5. It ignores the ruling of the Commissioners of the General Land office, in a particular case, "that the township line is also the boundary line of those sections immediately south of it; and that the setting of a corner beyond or short of it does in no way change the place of the boundary line."

6. This interpretation of the law would produce a conflict of interest.

The possessor, say on the north of the boundary line, by this ruling, holds to the original boundary; while the possessor on the south, by the same law, holds to the modified line—thus producing a conflict of interest when the subdivisional lines extend across the boundary, and thereby perpetuating and intensifying the difficulty, the law fixing the interior corners, was designed to obviate.

The anomalous character of this case, as compared with that of an interior corner, is seen in the fact that in the boundary two lines may occur, thereby producing the conflict of interest referred to, while in the interior of the township no such case can occur.

It is evident that the case under consideration was never thought of, much less was it provided for by the law-makers,

when they provided that the lines and corners, as returned, should be regarded as the true lines and corners. As a consequence, to consider the law as applying to this case, would be a stultification of the law, an act that courts and law-makers are not often guilty of.

As before shown, the ruling of our Illinois friend would give to each of the two contestants the same legal right to the same piece of land.

Now, when we can find an intelligent court in the United States that will eject either of these parties to make room for the other, we will admit that there is some merit in the logic of our Illinois friend.

Until that time come, I do not know what can be done with a corner that has been set beyond, or short of the line, more than to use it as a means of finding where the section line intersects the town line, at which place the county surveyor may proceed to plant a *new corner*, though, perhaps, he may not disturb the old one. H. C. PEARSON.

BOTH'S SECTION-LINER.

CORNELL UNIVERSITY,
College of Civil Engineering.
ITHACA, N. Y., March 16, 1890.

A. C. BOTH, *Civil Engineer.*

DEAR SIR:—This college of Cornell University has had in use, or in its collection of special instruments, every variety of "Section-Liners" it has been able to procure.

I have no hesitation in saying that the one purchased of you a few weeks ago is the best one yet brought to my notice, and is simple, reliable and satisfactory for its purposes.

The use of all other Section-Liners has been abandoned here, and yours is exclusively employed. I am Sincerely Yours,

E. A. FUERTES.

Director Coll. Civil Engineering.

See Advertisement, page 29.

HARDENING AND TEMPERING OF STEEL.

MR. HODGMAN, secretary, came to me last Friday, and wanted to know if I could not read a paper on Steel. I told him the time was rather short and that I could not give much of a paper, but perhaps I could give a little talk on the subject; but to do anything like justice to it, would require a large amount of space and time.

What I will try and do in this brief talk is to give a few hints on the subject from the best firms and experimenters, together with a few illustrations of work done by myself.

Oftentimes engineers and mechanics are away from good steel workers, and have a cold chisel, drill or other tool they want tempered. Of course, there is the country smith somewhere in the county who will undertake to do it. If he happens to make a good job once, he will tell you that he can temper anything; but the chances are where he succeeds once he will fail a dozen times, and then he has no end of abuse for American steel. "It is poor American steel. If I just had a good piece of English steel, I could make a chisel that would skip anything." But if you should get the best English steel, he would not hit it every time, and, of course, when he didn't, it would be a "poor piece." I find the word *English* has a wonderful effect on steel, or rather has had in the past. A man in Cleveland, who sells all kinds of steel, told me this summer that he had one firm that he could not get to use a piece of American steel. He got the firm to let him take a skilled steel worker in and make some tools, show them how to work the steel and what it would do, then the men would not use it. The proprietor was satisfied that the American steel was good and would like to use it, but no persuading would make the men do so. The steel merchant said he would put an English name on the steel. This was done and the steel did most excellent work, "Quite English, you know." This steel was, as I am glad to say, from the Detroit Steel Works of this city. The best tools I ever used were made of Detroit and Crescent Steels.

The Crescent Steel people, of Pittsburg, are taking untold pains with their steel, and for myself, I would rather have it than any English steel I have ever used.

WHY STEEL HARDENS.

One word about why steel hardens. I have been asked this question often, but have had to say I could not tell, nor have I been able to find out. If we did know, it would probably be an explanation to some of the curious freaks it takes. I will

give, however, what is generally thought to be the best theory I believe. Still this is merely a theory. Now, the theory is this:—

Steel is said to be composed of molecules of iron held in a fixed correlative position by virtue of the molecular forces, and between contingent molecules there exist certain known physical pores. It is conceived that carbon is absorbed and retained within these pores by force of attraction exerted by molecules of iron and atoms of carbon. The molecular force of attraction is opposed by another force which is due to heat, and the balance of these forces is called the resultant force. These forces exerted by continuous molecules being balanced in each physical pore, each force represents a distinct resultant force. Therefore the resultant forces may vary in different pores. If so, the absorption and retention of carbon will not be uniform. Any variation of temperature in any part of the structure will cause a corresponding change in the resultant forces in such pores as are subjected to such changes, and as this force attracts more or less carbon in proportion to its intensity, it follows then that the change of temperature in any part of the structure causes a redistribution of carbon. Hence, it may be concluded that, though the molecules of iron are fixed in a correlative position, the carbon is transitive, subject to be drawn from pore to pore as the resultant forces exerted at each point change.

Now the heating of the steel has the effect of dilating the metal and giving to the molecules a mobility necessary to enable them to unite; the sudden cooling bringing them rapidly together causes combination. Caron regards the hardening of steel as the result of this combination. Others consider that the molecules are in a state of agitation and that their edges (if we can speak of them thus) are moving in all sorts of directions and that the sudden cooling fixes them in this position.

Now, these are theories advanced by some very prominent men and I have given them to you about as they are found in Janes on The Steel Manufacture.

PROPER WAYS OF HEATING STEEL.

The open forge fires, such as are used in blacksmith shops, are the most convenient ways of heating simple pieces of steel; but, if the piece is long or of much value, this is not a good way of heating. If you have no other means, then bank your fire with fresh coal, place a piece of iron, say two or three inches in diameter, inside the fire, then get it to burning enough to coke the coal a little. As

soon as this is done, pull the iron out and you will have a hollow space for heating the steel, and if you work the fire slowly, the steel will heat evenly. Another good way is to bank a piece of steam pipe in the fire and put the steel in it. This I think is best, as it protects the steel from the action of the fire.

A good way of heating very valuable pieces, where we are quite particular about an even heat, is to take and melt lead in an iron dish over the fire. The lead should be covered with charcoal to prevent the surface from oxidizing, then the lead can be heated to the red heat and the steel placed in it. This gives a very even heat.

Another way of heating is in a gas fire. Where it is possible, this is perhaps the best way, if we have cheap gas. I will give one very crude fire that may be of service to engineers out in the woods and away from forges. Take a little good dry wood and start a fire; when the coals begin to form, place your drill or other tool in them. The drill will heat red hot; then with one hammer as an anvil draw out the drill with another hammer, and temper as I will describe later on.

We have shown how to heat steel, but we also have to employ some element to do the chilling or hardening. The quicker we chill a piece of steel the harder it is. The hardening may be done either with solids, liquids or gases. Most of the hardening is done, however, with some form of liquid. But I am inclined to think that gases can be used more than they have been.

The solids used are sealing-wax, tallow, lead unmelted, and other substances. The liquids used are very many; the most common I will give: water, salt and water and mercury. So far as I know air is about the only gas used, although Jarolimich, superintendent of works on the Danube, has shown that the hardening of steel has been done in steam. He also states that hardening of steel has been very poorly understood, and that it does not harden in the manner generally supposed. His experiments show that steel may be hardened in hot water, boiling oil, melted led and melted zinc, when it is cooled to 752° F.

These facts are rather surprising when hardened steel will soften on being heated to about 400° F. However, if the steel is heated somewhat above that of the melted zinc, say 150°, and plunged into the zinc, it will harden, but if left in the zinc it again softens. We can conclude that the hardening of steel does not depend altogether on being plunged into a very cold

liquid, but depends on the rapidity with which its heat is taken from a high degree to a lower one.

Now the question might be asked, Why not use warm liquids and heat to correspond? Steel hardened in very hot liquids is not very hard and cannot be from the fact that the hardness does not depend merely on the conductivity of heat by the liquid, but also on its power to absorb latent heat, and having a low boiling point. Now I think we come to a very important point in the hardening of steel. If we wish it very hard, use a liquid which will carry a large amount of latent heat and conduct heat well also. Then we can keep our steel at a much lower temperature, thus keeping the maximum stiffness with the minimum expansion.

The reason steel cracks on being hardened is because it is expanded by heat and when plunged into water the outside cools and shrinks, while the inside is still expanded, which causes cracks; but if we keep the expansion low, the steel may be elastic enough to keep from cracking.

I have found where it is possible it is well to have a hole in large pieces so as to cool the center first.

One word about water. I have had men say to me that they could not use the steel on hand, that it was bad, etc. One case I remember of in particular, where the workman could not temper the steel without heating it very high, and then it would crack. I tried it myself and had bad luck. I tried again, with no better results, and made up my mind that the steel was not good.

The next day, however, I tried another piece tempered in condensed steam and it worked all right. The trouble was the hard water. Sometimes if you do not remove the scale from steel, it will not harden well.

When a moderate degree of hardness is required and the piece is very valuable, it is well to use oil; this leaves the steel a little tougher than water does.

It is always well to harden only a little harder than we need to for the work it is to do, as we can keep the heat low. However, it is not possible to harden steel just to the right degree without we have a large number of pieces to harden of the same kind, size and out of a constant steel; so it becomes necessary to make the steel a little harder than we need and then reduce the hardness by applying heat. This is what is known as the tempering process. If the surface of the steel is polished after it has been hardened and is heated to about 450° F. there will appear on the surface at first a pale yellow, afterwards all of the colors of the spectrum down to dark blue.

The first is very hard and the last is very soft. This forms what is known as the tempering scale, and all degrees of hardness lie between the two extremes.

We have thus far found out how to heat steel, what to use in hardening, how to harden, and how to temper. Yet something should be said about the degree of heat. This is a point which I find men most ignorant in, and is the cause of untold trouble.

Tool steel should never be heated above a white heat and is better if it is not heated above the red heat, as the carbon at the high heats has too much affinity for oxygen and passes off.

I will give you one of the most important ways of ascertaining what heat to use. It was discovered by the Crescent Steel Works of Pittsburg.

"We take a bar of steel of ordinary size, say about an inch by a half, heat six or eight inches at one end to a low red heat, nick the heated part all around the bar, at intervals of half to three-quarters of an inch, until eight or nine notches are cut. This nicking is done at a red heat to determine the fracture of the nicks. Then place the end of the bar in a very hot fire, leaving the balance of the bar so much out of the fire as to heat it chiefly by conduction. Heat the end of the bar in the fire to white hot, or until it scintillates, and allow it to remain until the nick farthest from the end in the fire is not quite red, and the next barely red. Now, if the pieces be numbered from one to eight, beginning at the outer end,—

"No. 1 will be white or scintillating.
"No. 2 will be white.
"No. 3 will be high yellow.
"No. 4 will be yellow or orange.
"No. 5 will be high red.
"No. 6 will be red.
"No. 7 will be low red.
"No. 8 will be black.

"As soon as heated as above described, let the bar be quenched in cold water, and kept in the water until quite cold. After cooling, the bar should be carefully wiped dry, especially in the notches. An examination of the different parts by the file will show the following, if high steel has been used:—

"No. 1 will scratch glass.
"Nos. 2, 3 and 4 will be excessively hard.
"Nos. 5 and 6 will be well hardened.
"No. 7 about hard enough for tap teeth.
"No. 8 not hardened.

"In breaking off the pieces, which should be done over the corner of an anvil, and the pieces caught in a clean keg or box to keep the fractures clean and bright, it will be found that

"No. 1 will be as brittle as glass.

"No. 2 will be nearly as brittle.

"Nos. 3, 4 and 5 will break off easily, each a little stronger than the other.

"No. 6 and 7 will be very strong, and much stronger than No. 8 or the bar unhardened.

"Place the pieces in the order of their numbers, fitting the fractures. Then 'up end' each, beginning with No. 1 and following in the order in which they lie, and the result will be the series of fractures, as shown in Plate XXII, each differing from the other.

"No. 1 will be coarse with a yellowish cast, and very lustrous.

"No. 2 will be coarse and not quite so yellow as No. 1.

"No. 3 will be finer than Nos. 1 or 2, and coarser than No. 8, and will have a fiery lustre.

"No. 4 will resemble No. 3 in color and lustre, with somewhat finer grain, and will be coarser than No. 8.

"No. 5 will be of about the same size grain as No. 8, but will have fiery lustre.

"No. 6 will be much finer than No. 8, will have no fiery lustre, will be hard through and very strong. This is what is called refined by hardening.

"No. 7 will be refined and hard on the corners and edges, and rather coarser and not quite so hard in the middle. This is about the right heat for hardening taps, milling tools, etc., the teeth of which will be amply hard, while No. 8 illustrates the original grain of the bar.

"In almost every case the bar will crack along the middle to the refined piece (No. 6). In the illustration the crack shows very plainly in No. 4. This crack has never been known to extend into the refined piece, although the experiment has been many times repeated."

From this experiment the following conclusions are drawn concerning the effect of heat upon steel:—

"1. (a) A difference in temperature sufficiently great to be seen by the color will cause a corresponding difference in the grain. (b) This variation in grain will produce internal strains and cracks.

"2. A temperature so high as to open the grain, so that the hardened piece will be coarser than the original bar, will

cause the hardened piece to be brittle, liable to crack and to crumble on the edges in use.

"3. A temperature high enough to cause a piece to harden through, but not high enough to open the grain, will cause the piece to refine, to become stronger than the untempered bar, and to carry a tough, keen cutting edge.

"4. A temperature which will harden and refine the corners and edges of a bar, but which will not harden the bar through, is the proper heat at which to harden taps, rose bitts and complicated cutters of any shape, as it will harden the teeth sufficiently without risk of cracking and leave the body of the tool soft and tough, so that it can yield a little to pressure and prevent the teeth tearing out."

To test a piece of steel, take and draw it out into a cold chisel of about 30° or even 20°, then sharpen to 60°; if it cracks in this process, it is of no use; but if not, heat to the proper heat as indicated by the Crescent people's method, and plunge into water at 60° or 70° F. and draw the temper to a blue. If this chisel stands up well on wrought iron, it is very fair steel, but if not, it is probably poor. It is well, however, to try a second or third test. If it breaks, it may need to be a little softer, or if it turn, it may be made a little harder; but, if it will not temper hard enough to keep from turning without breaking, the steel is of no use. C. G. TAYLOR.

W. K. MUIR, Pres. and Gen'l Mangr., Detroit. S. D. MILLER, Secretary, Detroit.
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MEANS EMPLOYED IN RUNNING A STRAIGHT LINE.

THE most important instrument used in running a straight line, is a well-adjusted transit. There are so many text-books which give full directions for adjusting instruments, that that matter will not be discussed here. Next, and equally essential, is a firm, solid foundation upon which the transit is to stand. Swamps and marshes are not the only places where the shifting weight of the transit-man will throw the telescope out of line sufficiently to produce one of those eye sores known as "swings." Made ground in cities and villages, which has been formed by making the original hole a dumping ground for brush and rubbish, and then covered with a thin layer of earth for grass to grow, or holes filled up with slabs, listings, saw-dust and shavings, then sodded over, are often more unstable than swamps. In such places it is difficult to drive stakes for a good foundation. Even if they can be driven down, some part of the incongruous mass will be quite sure to throw most of the weight of a man against one of them. As soon as he changes his position the instrument will be disturbed. A hub should not be placed near a large tree in river or creek bottoms, nor in swamps, as a very gentle breeze will sway the tree enough to shake the ground for a distance of twenty or thirty feet from it.

In a swamp where the muck is more than ten inches deep, it is well to drive three stakes. They should be driven in the direction which the tripod legs will stand when set up, for obvious reasons. Sometimes the muck is so deep, that when large, long stakes are used, one position must be maintained if the transit is kept in line. In such a case one man should be called back and placed behind the transit. When both have found a position where they can move their bodies above the hips, sideways, without disturbing the instrument, the transit-man will turn the vertical hair on the back sight, reverse the telescope and allow the man to place the color pole. The operation should be repeated several times—the men changing sides—to insure accuracy. In the winter time, shaded places should be selected to set up on, especially if the temperature is above the freezing point. Then, the transit must be watched constantly, for it will surely settle off of the tack, and may have to be re-set four or five times if it stands over a hub half an hour.

There are many methods used by different persons for projecting a point in a right line. One, which is time honored, is to have a back flagman hold a color pole over the last

point. This is a good way, provided each one has done his part of the work correctly, but it leaves no backsights standing, so that you can check on them when set up in favorable locations. The back flagman must be skillful and able to hold the color pole perpendicularly over the point. He must not be sleepy, and always ready for business when needed. A man of such qualifications cannot always be found, so backsights, made from small, straight saplings, have been made to take his place. In an open country, these backsights are usually beveled at the top, leaving a ridge about an eighth of an inch wide. The backsight is plumbed up back of the transit, before pulling up, with the ridge placed just back of the eye-piece of the telescope. Through the woods, two pieces of paper, or two pieces of bark, with the light side forward, are fastened crosswise to the backsight with a tack. The paper, or bark, reflects considerable light, and it can be more easily found. The tack, or beveled top, when placed at the eye-piece of the telescope, is the point used in sighting back.

It is well to instruct the head chainman to drill a hole in the ground six inches back of the hubs, to set the backsights in. He should have the color pole placed with the instrument, before drilling the hole, then when the backsight is placed in it, and the tack, or beveled top, placed to the eye-piece of the telescope, you will know that it is plumb.

There is still a better way. Have a man set numerous sights ahead of the instrument. Pieces of card-board or paper can be tacked to fences, small sticks driven into tops of stumps, or ordinary backsights set up. When sights like these are placed as often as every two hundred feet, there will be little chance of error.

A backsight set in the ground, may be pried out of line by a root, or other substance, so slowly that it will not be noticed unless there are two or more fixed points by which the movement can be detected. With so many different kinds of sights, set by the aid of the instrument, any disarrangement of them will be quickly noticed, and can be corrected before any damage is done.

In setting tacks in hubs for transit points, if the color pole is bent or inclined slightly, or if the shoe is not set so that its point is exactly in line with a perpendicular line running through the center of the color pole, the tack will be out of line. When only a portion of the color pole can be seen, it may be held awkwardly and the tack placed considerably to one side.

With several sights to look back at, errors in transit points will be discovered, *because you have two or more points in a straight line to check on.* If only one backsight is used, or if a color pole in the hands of a back flagman is held over the last tack, the point taken from either is assumed to be correct. The transit point over which the instrument is set is also assumed to be correct. Now if the assumptions are true, there will be a straight line.

We have seen how a backsight set in the ground may be pried to one side. The back flagman and his color pole are liable to the same errors that may occur to the head chainman in setting transit points, so it is a risk to assume anything.

The conclusion that I have reached in this matter is, that it is best to use the back flagman in setting as many sights as he can put in, and put the cost of his color pole toward making a perfect one for the head chainman.

The head chainman, or the man who carries the color pole, selects places to set up on, and gets the transit points, is a very important factor in running a line. Nearly as much depends upon him for accuracy and speed as upon the transitman. He should be thoroughly drilled in everything in his line of duty. He should be taught to hold a color pole perpendicularly, by clasping it lightly between the thumb and forefinger of both hands, and the hands held above the head. The point should be lifted a little above the ground or hub. He must keep it squarely in front of him, and move his body the same distance that he does the color pole, when getting a point. As soon as the "All-right" signal is given, let go of the pole. It will fall vertically and make the point plain. If the pole is held to one side it is apt to have some uneven pressure given which will make it incline more or less.

It is quite certain that a man cannot stand awkwardly and hold a color pole accurately. He must be able to judge of the firmness and stability of the ground to set up on. He must select places where the longest sights can be had, and in running through timbered country, he should select transit points where the ground begins to ascend or descend. If any deep ravines or gullies are to be crossed, he must select points to get across them with the least possible chopping, and without having to set up on the steep side hills. He must know something of the reflection of light, so that when he goes to select a point, he will not get on the shaded side of a big tree, but get where the most light comes in through the leaves. A small limb cut out of the way will often let in a wonderful amount of light, or a white handkerchief spread over the

chest, or a light colored straw hat held in the right position, sometimes reflects enough light to show up clearly, objects which before were blurred and indistinct. In fact, he must be a man of gumption and equal to any emergency.

But he cannot do good work unless he is provided with a good color pole. It should be made from a good piece of straight-grained timber. I have found white, or Norway pine to be the best. It is fitted at the bottom with a shoe made from gas pipe, with a steel point welded on, and finished by turning down in a machine. The shoe ought to be of sufficient weight to bring the center of gravity within two feet of the bottom, so that it will have a greater tendency to hang vertically when held up.

The sizes of color poles vary according to the place where they are used. If one is dressed down with planes to a six or eight-sided stick, tapering slightly toward the top, it will keep straight much longer than a stick turned in a lathe. I do not know of any way, however, that one can be made which will never warp or bend. The shoe should be made of sufficient size to receive the stick, without dressing it down to go into the socket. Several trials will have to be made before they can be fitted to each other correctly. When finished it should be thoroughly tested, to see if the point of the shoe has been set in line with the center of the pole. To make this test, suspend a plumb bob from a point in a ceiling, and mark on the floor the point carried down. Fasten a string in the center of the top of the color pole and suspend it from the same point. If the point of the shoe covers the mark on the floor it is all right. Prying with a color pole should be prohibited.

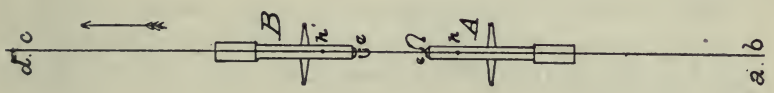
These remarks about the head chainman and color poles may seem extended and to deal with tiresome details, but it is exasperating to a trained man to take a good transit into the field, use care in keeping it in adjustment, and then have all of his pains go for naught, on account of a "chump" or a crooked stick.

A friend of mine exhausted his patience and his supply of men, trying to find one who could do the simple act of holding a color pole plumb, and as a last resort, had one made with a shoe so heavy that a man with ordinary strength could not hold it in any other position.

Sights should be equal in length if possible. None of them less than 200 feet, and of as great length as signals can be seen and understood.

Hard winds and refraction make work very uncertain. Clear, cool days are the most favorable for fine running.

A man may select the best transit, a well-trained head chainman, a perfect color pole, and use every precaution in running a long tangent, and when he has finished, may be greatly vexed and mortified to find instead of a straight line, he has run an arc to a circle, which has a long radius. If he starts out to review his work by repeating the work at each hub, he may discover no inaccuracies there, but can only see that it is a curve, as he looks at a large part of it at a time. I can only explain this in the following way: Some instruments have an eye-piece which is so large that when the eye is moved back and forth at right angles to the line, the cross hair appears to travel across a fixed point. Most men stand on the same side of the line and use the same eye, when looking either backward or forward. Now, suppose a man stands at the right side of the line and uses his right eye, and



has a transit of this kind. In the drawing let A represent the telescope pointed backward toward the backsight, and B the telescope reversed over the same point and *b c* the line of collimation, *h* and *h'* the cross hair. Standing on the right side of the line, the eye will naturally be on the right side of the line of collimation. When looking at the backsight *a*, the telescope will be clamped when the cross hair covers the point, but instead of the telescope pointing toward *a* it really points to *b* in the line of collimation. So when the telescope is reversed and the man endeavors to set the point *c*, he will set the point *d'* which is in line with his eye *e* and the cross hair *h'*. The distances from *a* to *b* and from *c* to *d* are slight and nearly equal, and the points *a* and *d* are points in a curve, tangent to the line of collimation. If the work is reviewed from hub to hub this error will not be noticed. Only when a number of them are seen on one side of the instrument will the curvature be apparent. There is also a personal error which enters into line running. It is also noticable when two persons run levels over the same line. The error is quite uniform and may of itself produce a slight curvature.

It would seem then that if a man ran a straight line of great length without error, he will do well to divide the credit about equally between his skill and good luck.

GEORGE L. WELLS.

Mr. Sears.—"I would like to ask Mr. Wells whether he relies upon his transit in getting a straight line without getting a double center. The only way to get a straight line is to reverse the transit and take a second point and get the center."

Mr. Wells.—"I should do this if the transit were out of adjustment, but I keep my transit in adjustment so that it would make no difference."

Mr. Hodgman.—"I would ask Mr. Wells, in the case he mentions, where there is an apparent motion or traveling of the cross wires, whether he noticed if the lenses in the telescope were properly focussed."

Mr. Wells.—"It was fixed on the object."

Mr. Hodgman.—"If the eye-piece was not correctly focussed on the cross wires, it would cause the apparent traveling of the wires."

Prof. Davis.—"I think you will get rid of that trouble if you test the eye-piece."

Mr. Sears.—"If he always takes double centers with care and skill he will be all right."

Mr. Hodgman.—"That is a sure way. I seldom do it, because I keep my instrument in good adjustment. I use backsights with a fine point, and leave them all standing where set. It often happens that from some point I can get a range back over quite a number of these points. Then if the instrument is the least bit out, I detect it at once and apply the correction. It is very seldom that I run a line for any considerable distance without an opportunity of this kind for checking up the adjustment of the instrument, as well as testing the accuracy of the line."

Prof. Davis here exhibited some light transits made by Buff & Berger, of Boston. "One thing the gentlemen will want to know is the price. They cost just about as much as a larger instrument. The work is finer on them. They will do just as good work as the larger instruments. An instrument of that size has been used in extensive triangulations, with accurate and satisfactory results."

Question.—"How close do they attempt to read them?"

Prof. Davis.—"Mine is graduated to read to half minutes. That instrument you have weighs 5½ pounds. The tripod weighs the same. For one, I have got through carrying about a twenty-pound transit on my back. I could tell you any number of stories in regard to the work of this little instrument. It is large enough for any ordinary use."

Mr. Wells.—"How about leveling with the transit?"

Prof. Davis.—"I must express my want of confidence in the level made on the transit instrument. For ordinary surveying, for sidewalks, etc., the level on the transit may be used."

Mr. Sears.—"Mr. Davis must excuse me if I am prejudiced against these small instruments. They are badly agitated by the wind. They have been lightening the tripod, and now they are lightening the instrument. I would like to see a man manipulating this in a cold day. It is well enough for a young man to get down to a fine point, but I prefer a large instrument."

Mr. Hodgman.—"Has Mr. Sears had any personal experience in the use of these light instruments?"

Mr. Sears.—"I have not. I would not use one of them."

Mr. Hodgman.—"Well, I have. From 1868 until 1881, when I went into the Denver & Rio Grande Western Railroad Survey, I used the heavy transit exclusively. When I went there I sold my instruments to the company. It was a hard place on instruments and I had a good many different ones in my party of all sorts of makes. The transit which did the best service and was every way the most satisfactory of any I had, was the lightest one of all, and was made by Young & Sons, of Philadelphia. It got to be pretty well known along the line, and not a little strategy was used by different transit men to get that instrument. In 1882 I purchased a Gurley light mountain transit, which I sold last year, and I now have another of the same make. I find by eight years' use of these instruments, that I can do as accurate work with them as I could with the large instruments. So far from being unstable, they stand more firmly in the wind than the large ones. They have just as broad a base of support on the ground, with very much less surface for the wind to get hold of. After fourteen years' use of the heavy transits and eight years of the light one, I have got so lazy that I would not take a heavy transit as a gift, and be obliged to carry it, if I could buy a light one at present prices. I have more confidence in the level on the transit than Prof. Davis

has. I used to feel just as he does about it. But I have always had a good deal of mixed surveying to do where I had to both run lines and take levels. This led me to make a number of extended and careful tests of the level on my transit, and I found, as the result of those tests, that the levels on the transits that I tested were plenty good enough for any work I have to do. Hence, I do all my leveling now with my transit and save lugging an extra instrument about the country when I have both kinds of work to do.

The following figures are taken from the notes of one of these tests. A line was run from Barron Lake to Niles with a Gurley Light Mountain Transit, leveling by stations with the transit as the line was run. It was then leveled a second time by stations with a 20-inch Gurley Wye Level. The following table gives comparative heights as taken by the two instruments:—

Station.	Height by Transit.	Height by Level.	Station.	Height by Transit	Height by Level.
0	100.00	100.00	175	75.17	74.91
25	115.03	115.39	200	74.10	74.17
50	109.36	109.25	225	72.73	72.77
75	106.84	106.90	250	65.18	65.31
100	94.86	94.93	275	34.66	34.92
125	86.95	87.39	279	32.04	32.32
150	77.65	77.98			

Mr. Davis.—"Mr. Sears has referred to his prejudices. Just as long as Mr. Sears is above ground we will respect those prejudices, and if he is going to lug a big instrument, we are going to let him, and the more years he lives to do it the better we will like it."

Mr. Wells.—"I used a small transit like Mr. Hodgman's and a large one side by side on the same work, and in closing there was a difference of about 2′ in favor of the larger instrument."

Prof. Carpenter.—"Other things than the size of the instruments may have caused the difference."

Mr. Hodgman.—"It is not so easy to read the smaller graduations, but I use a magnifying glass and have no trouble."

Prof. Davis.—"If the verniers are made correctly on the small instrument, there will be no difficulty in reading them."

YPSILANTI WATER WORKS.—ABSTRACT.

I HAVE been engaged during the past season in planning and constructing a system of water works for the city of Ypsilanti, and while there is nothing originally new or novel involved in the construction of these works, yet I think there is very much that is well worth the attention of all persons professionally or otherwise interested in such public improvements.

The plan of works adopted at Ypsilanti is based on the pumping and elevated reservoir service combined, both ordinary service and fire service being furnished direct from the street mains. There is a very broad distinction between the system of works I am here describing, and what is commonly called the pumping to stand-pipe system. Of all the water-works systems, where pumping is required, I claim the Ypsilanti system is the best in all respects.

It is superior to the pumping and open-earth-reservoir system, chiefly from the fact that the water in the perfectly enclosed elevated reservoir cannot deteriorate from exposure, as in the open reservoir. It is superior to the simple so-called direct-pressure service, both in economy and efficiency of service. In the direct service, an instant stoppage of our pumping machinery, and the entire service is dead. In no case can the service from such works exceed the simple capacity of the pumps. Nothing can be stored up for use in time of necessity, while to be prepared to meet extraordinary demands, we must keep expensive reserve machinery in constant readiness for use.

It is impossible to pump water economically in the direct service, because we never know what we have to do. At one hour of the day we may be called upon to run our pumps at their full healthy capacity, at another hour of the same day, perhaps only one-fifth of this service will be required, yet we must be ready at all times to meet all calls as they come. With our elevated reservoir we are perfectly prepared at all times for all emergencies. We can run our pumps at all times at the same speed, and under the same pressure, working to their full economic capacity, regardless of the current consumption; whatever excess of water there may be pumped, above the ordinary current consumption, will go to the reservoir, there to be stored to carry the night service when the pumps are idle, or to meet any demands that may temporarily exceed the pumping capacity.

To illustrate, we are building works for a small city where a half million gallons of water per day will be the maximum consumption for ordinary service. If we are to have a fire service, as well as ordinary service *direct* from the mains, we must be prepared to meet short calls for fire service, *four times* greater than this maximum ordinary service. If we are working under the simple, so-called, direct pumping plan, having nothing but our pumps to rely upon, then these pumps must be of *five times* greater capacity than needed for our ordinary work, and this excess must always be kept in readiness for *instant use*. The amount of water required for fire service for a whole year, averages less than *one day's* ordinary consumption, yet, to do this *one day's* work on the *direct* plan, we must keep our *four-fold* excess of pumping capacity in readiness for 365 days in the year.

In nearly all our public water-works systems the amount of water running to waste greatly exceeds the amount used for strictly necessary purposes. I think it is safe to say that seventy-five per cent of all the water used, escapes from faucets partially opened and constantly running. These openings are all gauged to give the required amount of water under the *ordinary* pressure; a fire breaks out, and at once the pressure must be doubled, your waste is doubled, and your fire service handicapped. Your pumping machinery is usually not adequate to meet all these demands effectively. Your mains are not large enough to carry this amount of water without a frictional loss that will very seriously impair the efficiency of such service as your pumps may still be able to render. In many cases your water supply will not be adequate to meet all these wants, and wastes.

The stand-pipe cuts so small a figure in water-works construction, considered purely on its merits, that it would not be worthy of any extended notice, but for the fact that the great majority of the people hold such vague ideas concerning it.

The original intent of the stand-pipe, was to provide a relief for the pumping machinery and mains against the shock of suddenly changing pressures. A stand-pipe of proper height, and in size equal to the force main, would serve this purpose as well as one of larger size. Of late years, stand-pipes of much larger size have become quite popular with many engineers. The only added merit these larger stand-pipes possess consists in their added storage capacity, and this is too small to cut any important figure. A stand-pipe fifteen feet in diameter, and one hundred and fifty feet high

will hold a little less than two hundred thousand gallons of water, counting from the ground up, and will cost ten thousand dollars, or five cents per gallon for every gallon of water it contains; if we enclose it, as ought to be done, then it will cost as much more. But only *one-fourth* of this water will do *effective work*, so that this raises the cost of our structure virtually to twenty cents per effective gallon, if naked, or forty cents per gallon if enclosed. Such a structure cannot do fire service longer than thirty minutes without reinforcement from the pumping station, nor can it do good ordinary service long enough to enable us to reduce the working force at the pumping station.

A properly constructed water works, on the pumping and elevated reservoir plan, should consist of a pumping plant of at least double the capacity required by the maximum consumption of the ordinary service, so that the full twenty-four hours' supply can be pumped by working half time, with one set of men, and a reservoir of sufficient storage capacity to carry the ordinary service during the night, and to meet the demands for fire protective service at all times. The reservoir must be placed at sufficient elevation to afford sufficient fire service by the simple gravity pressure of its waters.

In order to secure the best results, the pumping station and reservoir should be on opposite sides of the city, the street main distribution lying between. This arrangement will reduce the frictional loss in the mains to a minimum, and secure the highest degree of efficiency in the service. The pumps and reservoir will be connected directly through the street main distribution, and when the pumps are running, all the ordinary service will be supplied direct, the pumps always running up to their full economic capacity, without any regard to what may be transpiring throughout the distribution, the aim being to pump all the water in ten or twelve hours, that will be required during the twenty-four hours.

Of course the excess of water pumped, beyond the ordinary current requirements, will pass into the reservoir, there to be stored for the night service, and to meet any extraordinary demands that may arise. Should a fire break out during pumping hours, calling for water in excess of what the pumps are delivering, no attention need be given it at the pumping station, as the moment the pumps fall short of supplying the demand, the reservoir will come to the rescue with its reserve power, and both reservoir and pumps will work effectively and harmoniously together. It is now that the importance of a proper placement of our pumps and reservoir will most plainly

appear. If our pumping station and reservoir had been placed in juxtaposition, compelling both to work through the same main, from the same direction, instead of working in harmony and full effectiveness, there would be constant conflict and but half service could be rendered. It would not be possible to establish an effective, frictional equilibrium between the contending forces.

In planning and constructing the Ypsilanti Water Works, it has been my aim to harmonize all these elements, and to develop a service of the highest degree of economy and efficiency, and its natural advantages have been highly favorable to this end. Nearly three years ago I visited Ypsilanti, and made a preliminary investigation relative to the development of a public water supply. I found everything favorable to success. In April last the people voted to bond the city for seventy-five thousand dollars, the money to be used in developing a system of water works; I was employed by the Board of Water Commissioners to plan and superintend the construction of their proposed water works. In the commencement, it was deemed best to only put on about ten miles of street mains, with a small steam pumping plant and an elevated reservoir. Later it was found that an excellent water power, fully equipped for service, was available, and it was deemed best to purchase this water power, and abandon the steam pumping plant part of the plan. The adoption of the water power increased the first cost of the proposed works about twenty thousand dollars. As the work progressed, a demand sprung up calling for a large extension of the street mains, the result being that an additional fifty thousand dollars in bonds were voted, and additional mains were put down, until the total street main distribution reaches nearly eighteen miles. This gives Ypsilanti two and one-half miles of street mains for each one thousand of her population, which is more than double the average of the cities of the United States having water works, and renders her more perfectly equipped in her public water-supply service than any other city in the State.

This liberal provision in the outset has proven wise, and fully justified by the results. The people are more generally satisfied, as the entire city now enjoys the *full benefit* of the improvement, whereas with only ten miles of street mains, as at first intended, only about one-half the city would have been directly benefited. These works start out, from the day of their opening, as a *self-sustaining* public improvement. I think this is the first case of the kind on record.

The plan adopted in constructing the works will account for this. Utilizing our water power, we brought into requisition a temporary pump, and, taking water from the river, filled the mains as fast as laid, the object being mainly to provide water for puddling the back-filling of the trenches, and to furnish fire protective service from the hydrants as fast as set. In sixteen days from the opening of the first trench, we threw fire streams ninety feet high, direct from the mains in the heart of the city, three-fourths of a mile from the pumping station; and in ninety days all the street mains were in place, and the city fully provided with effective domestic and fire-protective service. Soon after commencing pipe laying, applications began to come in for permits to tap the mains for water for lawn sprinkling. This demand exceeded the capacity of the pumpers to meet, and kept in advance until the close of the season. Between four and five hundred connections were made before the close of the season, and before the works were completed and formally opened. Had the Board been able to keep pace with the demand of the applicants, there would doubtless have been eight hundred paying connections with the mains before the works were completed and formally opened. We did not wait for the completion of this branch of the work before starting in on other parts of the work, but commenced and prosecuted all simultaneously.

The water power and buildings of the Ypsilanti Paper Company, located in the southern part of the city, were purchased by the city, and the pumping plant located there. The supply well was located about one thousand feet from the pumping station, on the opposite side of the Huron River, which, running from north to south, bisects the city. This well consists of a circular caisson thirty feet in diameter, constructed of iron and masonry, the sides being impervious, and sunk to the depth of thirty feet, terminating in a stratum of water-bearing gravel. Fifteen feet of hard pan, of such tenacity as to require blasting, overlaid this water-bearing stratum. When the water was reached it overflowed the surface of the ground. This water supply is ample in quantity for the utmost requirements of the city, having been tested to more than three millions of gallons per day, and the quality of the water cannot be surpassed.

The pumps are conneted with this well by a sixteen-inch suction main, running under the river, in the same trench, and parallel with the twelve-inch force main. One and one-half miles from the pumping station, diagonally across the city, is located the elevated reservoir. The ground upon

which this structure is built is one hundred and three feet above city datum.

The reservoir is constructed as follows: First, a substructure of masonry, circular in form, forty-two feet in diameter, and eighty-five feet high is constructed. The walls are of Joliet stone, laid in cement mortar. The outer wall is in true circular form, three feet four inches thick at grade line, and two feet thick at top, or base line of reservoir. There are three parallel walls, at equal intervals inside, running entirely across and intersecting the outer or circular wall. These walls are each of the same thickness and height as the outer or circular wall. The excavation in which the foundation for these walls is laid, is circular in form, fifty feet in diameter, and covered solidly to the depth of six inches with very rich cement mortar. Upon this are laid the footing courses for the walls above. These courses are of dimension stone, laid in terrace form, each course being sixteen inches in thickness, the first course for all the walls being six feet in width, terminating at grade line in a course four feet in width.

Crossing the wall at top, in parallel courses two feet apart, at right angles with the walls, are steel floor beams ten inches in depth, for the reservoir to rest upon, the walls being built up between the beams, flush with their upper surface. These beams project thirty inches outside the masonry all around.

The reservoir consists of a steel tank, circular in form, forty feet in diameter and twenty-seven feet deep, and resting upon the floor beams and walls of the substructure. A sixteen-inch main connects the reservoir with the street main distribution, and an eight-inch overflow pipe leads to the sewer. This reservoir is entirely enclosed with a structure of wood. This building rests upon a circular plate of steel, bolted to the ends of the projecting floor beams, is circular in form, rises perpendicularly as high as the top of the reservoir, and from this line a dome roof is spread over the whole, terminating in a cupola with glazed windows in each of its four sides. There is two feet of clear space between the outside of the reservoir and the inside of the walls of the enclosure, and twenty-two feet of clear space from top of reservoir to base line of cupola. The cupola is two hundred and fifty feet above city datum, and will be provided with a cluster of electric lights.

The capacity of this reservoir is a little in excess of a quarter of a million gallons, which is thirty-five gallons per capita for the entire present population of the city, and *every gallon* of this water is always available for full, effective fire

service. The full reservoir will furnish six effective fire streams, for six consecutive hours, without reinforcement from the pumps. This reservoir will be ample to render full service to the city for at least five years, after which it can be duplicated on a corresponding summit on the opposite side of the river and city, a central twelve-inch force main leading from one summit to the other. This main is already laid. The present force main from the pumps through the distribution, is twelve inches in size, and runs through the main part of the city on the west side of the river. Five years hence the plan contemplates a duplicate twelve-inch main on the east side. The present arrangement will supply all demands up to that time, and the plan, when fully completed, will be better than if a larger *single* force main had been provided in the outset.

With the plan fully carried out, the pumping station and the two reservoirs will occupy the three points of a triangle about equidistant, with the entire street main distribution enclosed. Under this arrangement we will secure a very high degree of effectiveness in the service, the frictional loss of the water passing through the mains being very small. The street main distribution is so arranged as to give a double-discharge fire hydrant at every street intersection. The mains cross the river five times, giving full service to all parts of the city.

The pumps are power pumps of an entirely new pattern, are triplicate in form, and promise to give an exceptionally high economic duty. Running these works by water power will save much expense.

There is water sufficient all the year to operate the pumping plant, and for nine months in the year there is more than needed. The city will utilize this extra power to run its electric street lighting plant, which is now operated by steam power. The electric plant is being placed in the pumping station, and will be run by the same power as the pumps, when there is sufficient water; when not sufficient water, then by a Corliss engine attached to the same line shaft, being so arranged as to permit of instant change from water to steam, or the reverse. It is estimated that this arrangement will save the city five thousand dollars per year in running the two plants, as compared with running both by steam.

The cost of the Ypsilanti Water Works has been a little less than one hundred and forty thousand dollars. Ten thousand dollars of this, however, should be charged to the electric light plant, and five thousand dollars to the private service

development fund. This will leave the actual cost of the water works, one hundred and twenty-five thousand dollars. The elevated reservoir cost seventeen thousand dollars, which is about six and one-half cents per gallon of its waters. The interest on the cost of these works, and the current running expenses, will not exceed eight thousand dollars per year. The revenue from private rates will exceed this at the end of the third year, and the city council has only to credit the water works an exceedingly low rate for fire-protective service, to provide a sinking fund that will take care of all the bonds issued for the *entire work*, long before their maturity; and this without levying one dollar in taxes to redeem these bonds.

In the construction of the Ypsilanti Water Works, no contracts for work were let, everything being done by day labor.

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PHOTOGRAPHIC SURVEYING.

In consequence of a misunderstanding between the Secretary and the printers, the proofs of the article on Photographic Surveying in the Michigan Engineer's Annual for 1890 were not submitted to the author for correction.

The following corrections should be made:—

ERRATA.

Page of Proceed'gs	Line from top of page.	Word from beginning of Line.	Present Reading.	Correct Reading.
87	16	3	line	lines
89	26	6	commercial	photographic
91	24	6	in	from
91	24	10	the	omit
91	25	3 and 4		insert "from"
91	25	7	F	nearer the lens
92	13	1 and 2		insert "are made"
94	18	9	some	a
95	2	9	$\frac{n}{(n+1)2^1}$	$\frac{n}{(n+1)^2}$
95	11	5	movably	made
95	25	1	Set	Let
95	28	6	$\frac{1}{p}+\frac{1}{d}=(m-1)\left(\frac{1}{r}+\frac{1}{r^1}\right)$	$\frac{1}{p^1}+\frac{1}{d}=(m-1)\left(\frac{1}{r}+\frac{1}{r^1}\right)$
95	29	9	any definite	an infinite
95		Bottom	$\frac{1}{r}=\frac{1}{r}$	$\frac{1}{r}+\frac{1}{r^1}$
96	2		$F=P=\frac{2r^1}{(m-1)(r+2^1}$	$F=P=\frac{r\,r^1}{(m-1)(r+r^1)}$
96	4	14	p	F
96	5	3	v	r
96	8	4	P^1	p^1
96	11	Last half		and $d=p^1$, also $\frac{1}{p^1}+\frac{1}{d}=\frac{2}{p^1}$
96	12	10	No. 2	No. 1

ERRATA—Continued.

Page of Proceed'gs	Line from top of page.	Word from beginning of Line.	Present Reading.	Correct Reading.
96	13	Line	For large P	read small p
96	14		$\frac{P^1 d}{4}$	$\frac{p^1+d}{4}$
96	18, 19, 20, 21		For large P	read small p
96	20		$\frac{n}{(n+1)2}(P^1+d)$,	$\frac{n}{(n+1)^2}(p^1+d)$
97	11	9		insert "dimension of"
97	16	10	F is the	omit "is" after F
97	17		the focal distance of the lens	omit
97	24	End		insert "proportional to"
97	26		representing the actual area,	and R H the elevation of some point above it,
98	7	2	projectures	projections
99	20	3	$\frac{R\ R^1}{F^2\ T^2\ C\ R^2}$	$\frac{R\ R}{\sqrt{F^2+C\ R^2}}$
99	21		$\frac{S\ S^1}{F\ S\ S^2}$	$\frac{C\ S}{\sqrt{F^2+C\ O^2}}$
99	29		T times h°	F times tangent of elevation
99	32	5	area	omit
99	35	7	ten	"tangent"
101	11		$\frac{-2}{C\ B}2$	Distance from center, squared
101	15	6	of the focal	of the square of the focal distance
101	25	1	$\frac{b}{\sqrt{F\ a^2}}$	$\frac{b}{\sqrt{F^2+a^2}}$
105	21	3	on measure	are measured

PHOTOGRAPHIC SURVEYING.

THE theory or principle of this method of surveying is identically the same as used in plane table work, or, indeed, in any system of triangulation. We must have at least one measured base line, and then we proceed to take angles from various points to the objects to be located, not, however, by actually measuring them as in triangulation, nor by drawing lines toward required points as in plane table work, but by taking photographs which shall include the required objects as seen from at least two distinct points of view. These photographs serve every purpose that is required for making maps, giving not only horizontal angles, but also elevations or depressions, and the location of every object shown on photographs taken from two distinct points of view. All precautions regarding the selection of angles that applies in triangulation or plane table work holds equally true here. If radiating line from different points meet at an acute angle, errors are likely to result—greater as this angle is smaller.

Any method of procedure practicable in plane table surveying is equally serviceable in this. I will, however, describe but one method, that being similar to the one usually used in triangulation. First measure a base line, as *A B*, and also take its bearing, if it is desired to know the bearings of the other lines of the survey. Set up the camera at *A* and sight it on *B* and so as to cover some object toward *D*. If no fixed object can be seen at the termination or limit of view, a flag must be set; this then gives us the angle *D A B*. The next view would include the point *C* and *E*, making the angle *D A C*, if the instrument is sufficiently wide angled, if not it may be divided into two or more views. After taking all the sights needed at *A*, the instrument may then be moved to *B*, then with the instrument sighted on *A*, take as large an angle as possible toward the objects *D* and *E*, and continue until all the objects desired come onto the field of view. The pictures which may be obtained from these different views by a skilled observer,

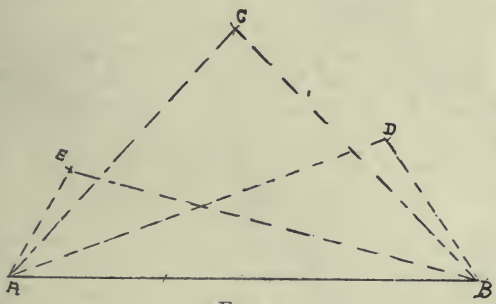


FIG. 1.

with the proper kind of apparatus, will provide accurate information regarding all these various angles. After securing two views on any point its location then becomes known, and the instrument may be moved to that point, after which proceed as in the first instance. Thus the field of operation becomes wider and wider. A practical limitation with this apparatus will soon be found, however, because of the small size of the pictures as compared with the objects, so that distant objects, unless they are very large or bright, can not be found on the picture. This limitation depends entirely on the lens used, the shorter the focal length of the lens, the less the distance objects can be seen.

This method of operation is no doubt comprehended by every one, because it comes directly within the province of the surveyor. The remaining operations involve work heretofore done largely by photographers, and, consequently, are new to our business. I know that surveyors have not been photographers, and at the risk of being tedious, I will describe the essential instruments and processes used in photography, although by so doing I may be going over work very familiar to many of you.

HOW TO PHOTOGRAPH.

The basis of modern photography is the dry plate. This consists of a plate of clear glass, or transparent film of celluloid, covered with an emulsion of gelatine made sensitive to light by the addition principally of bromide of silver. Some of these plates are extremely sensitive, and an exposure even as short as 1-50 of a second, is sufficient to give a clearly defined image. The action of the light changes the nature of the chemicals on the dry plate, somewhat in proportion to its intensity. This change is rendered visible by the application of certain other chemicals called developers. Even after an image is made to appear by the developers, the plate is still sensitive to light, and it must undergo a process called fixing before it can be exposed in white light. Red and orange light have little or no effect on these sensitive plates, and, consequently, they may be examined and handled by light passing through a ruby or orange glass. The necessity of thoroughly protecting these sensitive dry plates from the light when in transit is now seen. Various devices termed dry-plate holders are used for this purpose. They are so made that a shutter can be taken from in front of the dry plate and replaced, when the dry plate is in the camera, without exposing the plate to any light. If a dry plate were to be exposed in the open air, diffused light would act on it and no image would

appear, the whole plate would appear black after developing. There must be some means of concentrating the image desired and shutting off the effect of any other light. It is found that this may be done by a dark box with a small pin hole opposite the dry plate—quite creditable pictures have

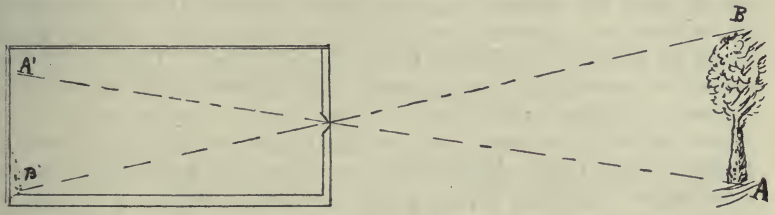


FIG. 2.

been taken in this way. This would be the simplest possible form for a camera. It would need no focussing arrangement; the size of the picture would depend on the length of the box, and the sharpness of the picture on the smallness of the hole. The principle of action is shown in the sketch, by means of which it is seen that the image is inverted as compared with the object. To cut off side rays of light the box should be painted black on the inside. Such a camera, though it might be accurate, would be exceedingly objectionable in practice; since if the hole were small enough to give a sharp image, even the most sensitive dry plate would be exceedingly slow, because of the reduced amount of light. From five to ten minutes exposure would probably be required.

The use of a lens virtually enlarges the hole for the admission of light and still concentrates the rays of light, so that pictures may be taken very rapidly. The use of a lens for photographic purposes is more trying, more difficult to satisfy perfectly, than for telescopic or microscopic purposes. A very short discussion will, I think, make this point clear to you without entering into any abstruse calculations. First, however, we will consider the commercial camera.

THE CAMERA.

The camera for photographic purposes consists simply of a box, the length of which can be changed at will, usually by connecting the back and front with a flexible bellows. In the front is arranged the lens, and in the back is a place fitted to receive the dry plate-holder. When not in use, a ground glass screen takes the exact position of the dry plate when in the act of taking a picture. The image of the object to be taken

is thrown on the ground glass, and by shutting off the side rays of light by throwing a blanket over the head, it can readily be seen. The length of the camera can be changed until each portion of the picture appears sharp and distinct, at which time it is in focus and ready for the picture. When the camera is level, the ground glass must be vertical. If it is necessary to incline the camera upward or downward, the ground glass must be inclined but little from the vertical. This condition requires a swinging back around a horizontal axis, technically called a single swing back. The back is also sometimes swiveled so as to swing on a vertical axis, technically called a double swing back. Both these attachments will simply make a surveyor trouble without ever being of benefit. The angles of his camera should be rigidly at right angles, as the least change of position of the dry plate is fatal to accurate work. One movable feature, and one only, is permissible in the camera for photographic surveying, and that is a sliding front board, by means of which the center of the object glass can be raised or lowered above the center of the camera. The effect is to raise or lower the field of view, through an angle whose tangent is equal to the distance moved from the center position divided by the focal length of the object glass. By means of a table of tangents a scale reading to degrees or even closer can be computed and marked on the front board. Pictures taken under such conditions can be reduced to equivalent horizontal pictures.

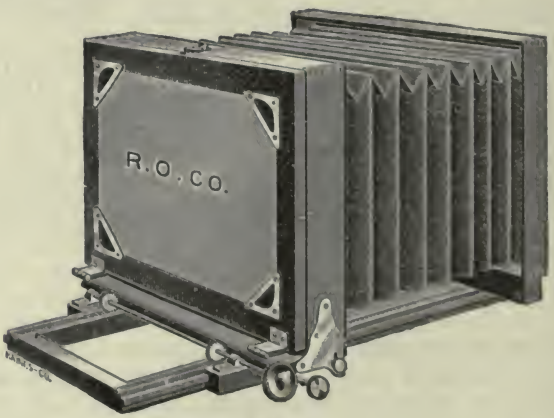


FIG. 3.

After considering the requirements and methods of testing lenses, the adjustments required for the camera will be considered.

THE LENS.

Let us consider for a moment the action of a lens in producing an image. Let *K L* be a double convex lens, *A B* an

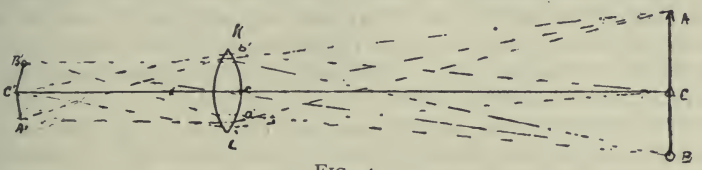


FIG. 4.

object in front of the lens. Rays of light from every point of this object radiate and completely cover the lens. Thus, for instance, from the point *A* in the object, rays of light strike every point of the object glass, for instance *a' e' c'*. These rays of light in passing through the lens are bent toward the perpendicular, and in leaving it they are bent away from it. The effect of this is to converge all the rays of light from the point *A* in the same general direction, or if the lens is perfect, to unite them at same points *A'*. In a similar manner the rays of light from *B* unite at same point *B'*, those from *C* at same point *C.'* We thus have the images of all points of the object formed somewhere back of the lens. These points may or may not be in the same plane, that is the point *C'* may be further from the lens than either the points *B'* or *A'*. In the case of a camera this condition would exist when we get a perfect image in the center of the picture and a confused one along the edges.

A study of the sketches makes another thing evident: as the distance to the object increases, the image approaches the lens, until when the rays of light are parallel the image is at its nearest position to the lens, or is said to be at its principal focus. This is readily seen in the above diagram; the parallel rays of light *A* and *B* meet at *F*, those from *C* meet at *C'*. Since the focus continually changes its position with reference to the lens, as the distance to objects vary, so is the image to be found in various positions. Now then, we find with this change of focus of the center, a change in the relations of the focal positions of the extreme points. That is, we might grind our lens to bring the points *A' B' C'* in the same plane for one position of the object, but we should find that a change in the position of the object would necessitate a new focus and consequently a different adjustment of these relations. The perfect lens for a camera is then a mathematical impossibility, as it involves a changeable form to the lens for each position of the object.

Possibly it needs such a lens as nature has furnished in the organ of sight, which acts under conditions more nearly like these of the camera lens than any other instrument.

That this limitation is less important for the telescope is seen at once, in the fact that we are interested in that case only with the center rays, or those near the center, and we put in stops or diaphragms to prevent any possible injury by interference of the side rays.

Having only the center portion of the image, the error in the shape due to different positions of focus at extreme edge and center, entirely disappears. Achromatic lenses, or those which do not separate the chemical rays of light, as is well known, by forming a lens of two kinds of glass, are even more important in a camera than in a telescope, since these chemical rays act with very different intensity on the sensitive plate.

We will call the first error described above aberration, and will say that it can be much lessened by using only the central portion of the lens to transmit light. This is done in the case of a single lens by placing a diaphragm, with a hole of a definite size in front of the lens. The diameter of this hole is generally some even divisor of the focal distance of the lens, and a large variety of diaphragms is provided with each instrument.

The error of aberration is also reduced by using two lenses in the object glass, placed a short distance apart. As seen from the diagram, the effect of the two lenses is to doubly refract the rays as compared with a single lens. This has the effect to bring the focus nearer the lens, and also reduces the distance between extreme positions of focusing. The effect of this is to reduce the error, or at least make it more nearly uniform, so if corrected at one point it will not be so badly out at others. Thus, with the single lens the focus would be at

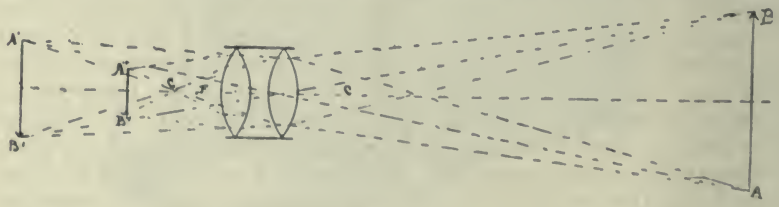


FIG. 5.

$A' B'$, but with the combination it is at $A'' B''$. Despite this improvement of the double lens over the single one, no maker claims to produce a lens without aberration, unless diaphragms are used as previously described. Then he cannot claim its

entire absence, but that it is reduced to so small an amount as to be invisible and immeasurable, at least with certain stops. This condition makes the lens practically correct. The purity of the glass is of as great or greater importance than the figure of the object glass, as every flaw, change of density or color, in time affects the image. In this respect each one of the past few years has marked great improvements, and it is believed that optical glass is now being manufactured that is nearly free from the defects mentioned. In regard to lenses for cameras, the best ones are probably produced in Europe. Dallmeyer of London, and Suter of Berne, are the two most celebrated makers. There are, however, a great many lenses made in this country, many of which are of great excellence. I have myself tried two of American make, the Morrison lens, manufactured by the Scoville Co., and the Bausch & Lamb, manufactured at Rochester, N. Y. In both instances the errors from aberration were less than could be measured. Either of the above makes, if as good as the ones tested by myself, would do satisfactory service in photographic surveying.

TESTING LENSES.

1. Lenses may be tested for aberration by focusing on objects very close and very distant and noting the relative sharpness of the image at the center and edges of the plate. If no diaphragm is used, the best lens made will show some defects, especially if a magnifying glass be used to examine the image. The best test for engineers is to arrange a series of objects at different distances and in different directions from some central station; measure these angles accurately with a transit, then afterward repeat the measurements with the camera. If there is any disagreement whatever, measurable, I should reject the lens.

2. The lenses may be tested for other defects by fastening them in the end of a long tube, with a place for the eye at the other. Make a diaphragm of paper with a small hole so arranged as to be movable and to admit light to different portions of the lens. If the lens is perfect, it will in all cases appear uniformly bright. The last is an important matter if we expect a lens to do satisfactory artistic work.

3. Rotate the lens in a tube; if any shifting of the image appears, the lens is defective, or at least not mounted correctly. This test is much the same as that used to test the line of collimation of a level.

4. Make a photograph of paper ruled in squares like cross section paper, having the photograph as large as can be taken.

If the squares are not of uniform size, or are not perfect in the photograph, the instrument is faulty.

FOCAL DISTANCE OF LENSES.

The focal distance of a lens is the distance at which the image is formed from the center of the lens for distant objects, and must be accurately known before angles can be measured from the photographs. Unless this distance is extraordinarily great, the focal distance of objects forty rods or farther away will not differ sensibly from those at an infinite distance. Hence the determination of focal distance for parallel rays can be used without sensible error for ordinary measurements. The focal distance is always given by the manufacturer of a lens; but so far as my experience goes, their statements are not accurate, and perhaps are intended only to be approximately true. At any rate, it will be necessary to accurately determine the focal distance for each individual lens. It may be done as follows:—

1. Approximately, by taking the lens from the camera and obtaining the focus of the sun on some screen. The distance from the center of the lens to the screen will be an approximate focal distance.

2. Draw a heavy black circle on white paper, say six inches in diameter. Arrange this on the side of a small box so as to remain vertical. Level the camera, and set its center the same hight as the center of the circle. Move the box toward or from the camera, keeping the paper parallel to the ground glass of the instrument, until the image and object are of equal size, in which case the distance from the ground glass to the object is four times the focal distance. This method is applicable only with a camera that will extend about twice as far as the focal distance of the lens.

3. Use the same method, but make the image one-half as large in linear dimensions to the object, in which case the focal distance is equal to 2-9 the distance between image and object. This can be used with nearly every camera.

4. Use the same method, making the image one-third the linear diminsions of the object; in this case the focal distance is equal to 1-5 the distance between object and image.

5. The focal distance may be computed from data furnished by measuring the size of the object, its distance and the corresponding size of the image on the ground glass, by direct proportion, as will be explained hereafter. If n be the

ratio of object to image, the focal distance equals the distance between image and object multiplied by the fraction $\frac{n}{(n+1)^2}$, or for great distances $\frac{1}{n}$.

MATHEMATICAL CONSIDERATION OF THE FORM OF LENSES.

At this point it seems necessary to investigate some of the relations existing between the form of lenses, size of objects and size of images, in doing which demonstrations will be given for the different cases cited under the methods of finding the focus of a lens.

Because of the difficulty of construction, the forms for surface of lenses are movably spherical. Rays of light in passing through them apparently all intersect at a point termed the optical center of the lens. Considering aberration zero, parallel rays from any point all meet at the same point. This point is in the plane of what is termed the principal focus of the instrument, and its distance from the optical center is the focal distance of the lens.

In the figure

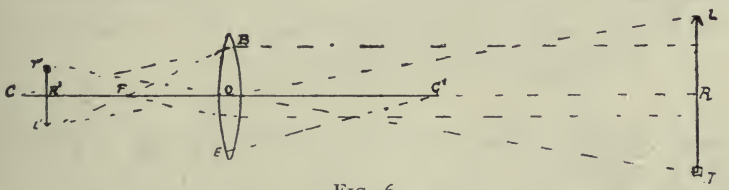


FIG. 6.

Let $C\ B=r$, radius of one surface of lens.
Let $C'\ E=r'$, radius of inner surface of lens.
Let $F=$ principal focus or focus of parallel rays.
Let $F\ O=$its distance to $O=P$.
Let $O=$optical center of lens.
Let $L\ T$ be any object and $L'\ T'$ its corresponding image.
Let $R'\ O=p'$, its focal distance.
Set $R\ O=d$, distance of object to center of lens.
Let $M=\frac{\text{sine angle incidence}}{\text{sine angle refraction}}=$index of refraction.
Then from any treatise on physics we will take the formula

$$\frac{1}{p}+\frac{1}{d}=(m-1)\left(\frac{1}{r}+\frac{1}{r^1}\right)$$

No. 1. For parallel rays the object is at any definite distance $\therefore d=\infty\ \frac{1}{d}=o$

Put $F=p$ $\qquad \frac{1}{F}=\frac{1}{P}=(m-1)\left(\frac{1}{r}=\frac{1}{r}\right)$

No. 2. Focal distance of parallel rays. For this case use symbol F instead of P

$$F=P=\frac{2r^1}{(m-1)\ (r+2^1}$$

r

No. 3. When $r=r^1$ $F=2\ (m-1)$

For glass used m varies from 1.52 to 1.56 equals about 1½. Hence p is equal approximately to v, or O F is nearly equal to C F. Since the rays of light intersect at O apparently we have from similar triangles $L\ T : L^1\ T^1 : : O\ R : O\ R^1$ letting $L\ T=b$ and $L^1\ T^1=i$.

No. 5. $b : i : : d : P^1$

$$\frac{b}{i}=\frac{d}{P^1}$$ or the relation of the size of objects to image varies

directly with the distance from the object glass. To consider the case when objects shall equal image—in this case $b=i$ $\therefore$ $d+p^1$ and $\frac{1}{p^1}$ equals $\frac{1}{d}$ or $\frac{1}{p}+\frac{1}{d}=\frac{2}{p^1}$.

Hence from No. 1 $\frac{2}{p^1}=(m-1)(\frac{1}{r}+\frac{1}{r^1})$ But in No. 2 we see this is the value of $\frac{1}{P}$ $\therefore$ $\frac{1}{F}=\frac{2}{P}$ or $F=\frac{P^1}{2}$ since p^1 equals d

No. 6. $F=\frac{P^1\ d}{4}$

Hence the principal focal distance is equal in this case to one-fourth the distance between object and image, as previously stated.

If the image shall be in linear dimensions ½ size of object, then $b=\frac{1}{2i}$ and substituting as before $f=\frac{2}{9}\ (P^1+d)$. If $b=\frac{1}{3}\ i$, $F=\frac{3}{16}\ (P^1+d)$, if $b=\frac{1}{4}$, $F=\frac{4}{15}$ (P^1+d). Or in general if n equal the ratio of object to image, we shall have

No. 7. $F=\frac{n}{(n+1)\ 2}\ (P^1+d)$, but since $n=\frac{d}{P}$,

No. 8. $F=\frac{\frac{d}{P^1}}{\left\{\frac{d}{P}+1\right\}2}\ (P^1+d)=\frac{d\ P^1}{(d+P^1)^2}\ (d\ P^1)=\frac{d\ P^1}{d+P^1}$. Since P^1 is

not separately known this last form is of little use. From No. 7 we see that when d is less with respect to P^1, n becomes correspondingly great, so that little error is made by omitting 1. Hence for distances exceeding 400 feet

No. 9. $F=\frac{P^1\ d}{n}$. Results must all be in same units. Correction for F to be deducted in case formula 9 is used.

Value P^1 d, feet.	Multiply F by No.	Value P^1 d, feet.	Multiply F by No.
25	.92	400	.995
50	.96	500	.996
100	.98	600	.9967
150	.98½	700	.9974
200	.99	800	.9975
250	.992	900	.9978
300	.993	1000	.9980

Since P^1 d is the distance from the image shown on the ground glass to the object, and on the ratio of object to image

or the number of times that the image is smaller than the object,—

We have this rule for the focal distance:—*Divide the distance between the ground glass, when the object is in focus, by the ratio of object to image. This will be the approximate focal distance.* Multiply by the number in the above table opposite the required distance, for the accurate focal distance.

REDUCTION OF PHOTOGRAPHS.

For distances used in the practical work of surveying it is seen that the actual focus will not differ sensibly or measurably from the focus for parallel rays. In which case we shall have this proportion, that the focal distance is to the image as the distance to the object is to the size of the object.

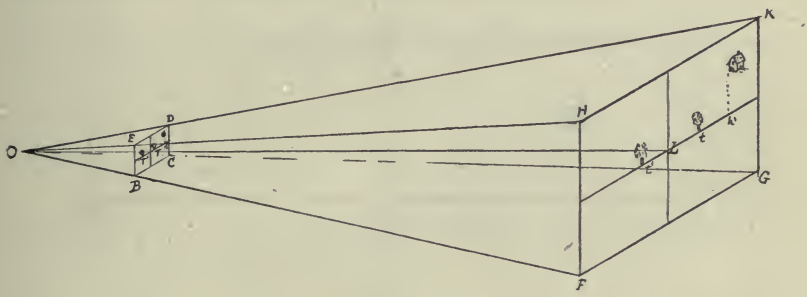


FIG. 7.

Thus in the above figure if *H K F G* is the vertical plane of projection of the actual area to be surveyed and *O* the center of view, then *E B C D* at a distance from *O* equal to *F* is the principal focal distance, the focal distance of the lens will be the picture. Let *O L* be a horizontal line drawn to the center of the field of view, then will *o l* equal *F*. The angle between any two objects as *t* and *t'* would evidently be the same as the angle between the image of the same objects on the picture, with its vertex at *O*. The distance on the horizontal line *T T'* reckoned from the center of the picture either way, is evidently the tangent of the angle, where vertex is at *O* and radius is equal to *F*. If *t t'* is a horizontal line through the vertical plane representing the actual area, the distance $\frac{R\ H}{\textit{distance from } O}$ would be the tangent of the angle of elevation.

This is evidently equal to $\frac{r\ h}{F}$ on the picture, so that the angle of elevation can be taken as well from the picture as from the actual landscape.

From this we see that reckoned from the center of a picture on a horizontal line, distances divided by focal length gives us the angle either to the right or left. In the same way angles of elevation or depression can be found by measuring on a vertical line through the object as represented on the picture. If objects are not on these lines, the angles between their projectures on these lines will be the required ones.

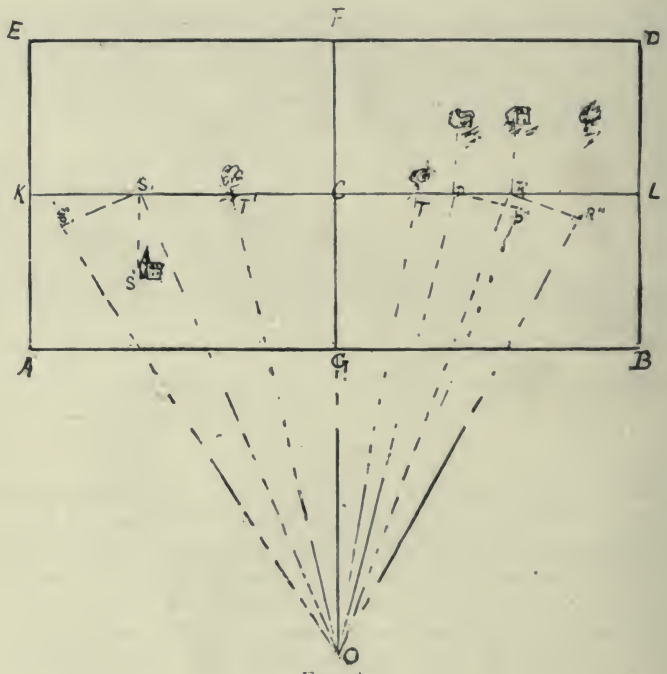


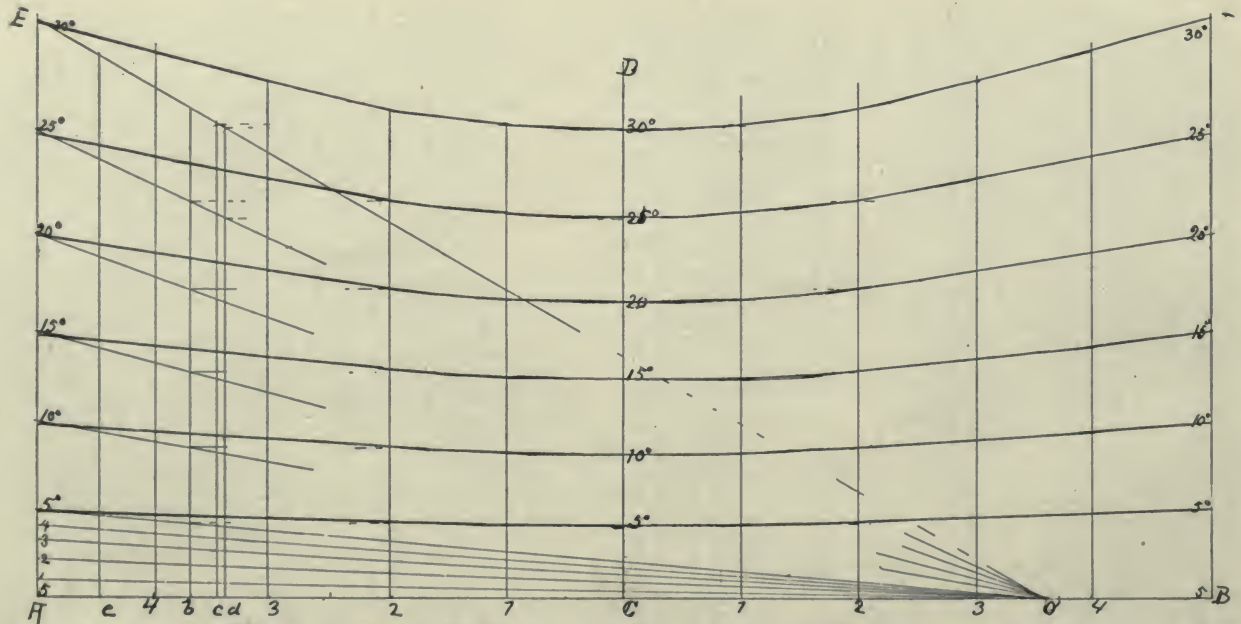
FIG. 8.

The actual process of reducing a photograph is explained by the above diagram, figure 8, which may be supposed to represent some of the prominent objects actually as they occur in the photograph. If the photograph is *A B D E*, the first thing to determine is the position of the horizontal line through the center of the picture. We will in this discussion suppose its position known, and draw this line on the photograph. Next determine the vertical line through the center of the picture, as *F G*. Their intersection at *C* is directly in line with the point of sight. Lay off from *C* in a vertical direction the distance *C o*, equal to the actual focal distance of the

lens; then will o be the horizontal projection of the point of sight. To find the angle between any two objects; first when in the horizontal line $R\ L$, as $T^1\ T$, draw lines from o to these points, then is $T^1\ O\ T$ the required angle. This may be measured with a protracter, or it may be computed, since it is the sum of two angles in the right triangles $C\ O\ T^1$ and $C\ O\ T$, whose tangents are respectively $\frac{T^1\ C}{C\ O=F}$ and $\frac{T\ C}{C\ O=F}$. If the objects are not in the horizontal line $K\ L$, as for instance $R^1\ S^1$, first project by a perpendicular into the horizontal line $K\ L$, R^1 will be projected at R, S^1 will be projected at S. Then is the angle $S\ O\ R$ the required angle which may be measured or computed as before explained. Tangent $S\ OC=\frac{S\ C}{F}$. Tangent $C\ O\ R=\frac{C\ R}{F}$. The angle of elevation of the object R^1 may be laid off and measured as follows: Project R^1 to R, draw $R\ O$, from the line $R\ O$ lay off $R\ R$ equal to $R\ R^1$ and in a direction perpendicular to $R\ O$. Draw $O\ R^{11}$ and the angle $R\ O\ R^{11}$ is the required angle. In a similar manner the angle of depression of the object S^1 is found to be $S\ O\ S^{11}$. These angles may be computed, since tangent $R\ O\ R^{11}$ is equal to $\frac{R\ R^{11}}{R\ O}=\frac{R\ R^1}{R\ O}=\frac{R\ R^1}{F^2\ \ T^2\ \ C\ R^2}$.

Also line $S\ O\ S^{11}=\frac{S\ S^1}{F^2\ \ S\ S^2}$.

The work of reduction is thus seen to be comparatively simple. We must know, however, the accurate position of the horizontal plane $K\ L$ and of the principal vertical plane whose trace is $F\ G$. We must also know accurately the focal distance of the lens. The work of reduction may be much simplified by drawing on transparent celluloid a scale of degrees and half degrees for every portion of the picture. This can readily be done since T times $h°$ is equal to the length of n degrees measured on the horizontal or vertical line. Thus from a table of natural tangents multiply each number by the focal distance of the lens area, lay the distances off on the horizontal line from the center of the picture either way, for a scale of degrees. Suppose for instance $F=7$ inches, length of 1 degree on horizontal line equal to $7\times$ten $1°=7\times.01745=.12215$. Length of $2°=7\times.0349=.2443$, etc., up to the number of degrees within the limit of the field.



Tangent Scale for Vertical Angles, for all positions on plate.

Tangents for Horizontal Angles 7 inch radius

Lay off these distances from O each way on the horizontal line A^1 B^1. Draw vertical lines through these divisions. This will then be a protractor which can be used for horizontal angles for all the work done with the lens in question, by making the center lines of the protractor agree with the corresponding lines on the photograph. The angles used will give the angular position of the object from the center of view. To make the protractor apply to vertical angles, lay off on the line C D the same diminsions as on the horizontal line. On A E and B F lay off tangents of angles multiplied by the square root of F^2 $\overline{C\ B}^2$, this brings the distance from the point of view to the edge of the picture, G or H.

Repeat the same operations for lines one inch apart between the edges and the center, the multiplier in this case being the square root of the focal distance plus the square of the width of the picture measured from the center. Draw lines through these points, which will be slightly curved, and these will be the measure of corresponding angles of elevation and depression.

To summarize the process, the tangent of any horizontal angle is equal, measured on the center line and from the center of the picture, to the distance on the picture divided by F the principal focal distance. Let a be the distance of the object to the right or left of the center and b be its height above a horizontal line; then tangent of any vertical angle is equal to $\frac{b}{\sqrt{F\ a^2}}$ The method of constructing this protractor for vertical angles is shown in the Figure 8. A B is a horizontal line through the center, C D the corresponding vertical line. Take any point as O^1 from which draw radiating lines any number of degrees apart, in this case 5° apart; these may be drawn by erecting a perpendicular one inch from O' and laying off the natural tangents of the required angles. This protractor being constructed for a lens of 7-inch focal length and for an 8x10 plate, the distance from principal focus to center, equals 7-inch distance, to 1-inch either side of center, and distance equals $\sqrt{50}=7.07$: to a point 2 inches either side $\sqrt{52}=7.28^1$; 3 inches either side $\sqrt{58}=7.69$, 4 inches either side $\sqrt{65}=8$. To a point, from point of view, at 5 inches from center $\sqrt{74}=8.6$. The products of the natural tangents of these various lines can evidently be obtained by drawing

vertical lines across these radiating lines at the required distance from *O'*, thus:—

At distance from *O'*, equal to 7 inches, erect a perpendicular, and where it intersects radiating lines will be the tangents for angles in the center of the plate. This in the figure is the perpendicular from *d'*; project these intersections over on the line *C D*, and we have the value on that line of tangents of angles 5°, 10°, 15°, 20°, etc., as measured from the center of the picture. Next erect perpendicular from *C*, a distance 7.07 inches from *O'* and project points of intersection with radiating lines on to perpendicular from I. I, the lines being one inch distance either way from the center of the picture. Do the same for all other distances, draw curves through these various points, and we shall have a protractor for degrees applying to vertical angles above the center. This reversed on the line *A B* would apply below the center.

In using this protractor distances from the center of the photograph can be measured by means of dividers; applying these to the scale above and we shall have the angle from the center of the picture corresponding to the measured distance. Such a protractor worked up on transparent celluloid could be applied directly to the photograph and angles measured without the necessity of using the dividers.

CENTER HORIZONTAL LINE.

The method of finding the center horizontal line of the picture is of utmost importance, as on its position depends all subsequent work with the camera. The method I used was as follows: After carefully leveling the camera, I set up vertical rods by means of the Y level. I found where the horizontal plane of the center of the object glass intersected these rods, and at these points I nailed cross bars that could be plainly seen in the photograph. I marked the position of the image of these cross bars on the ground glass of the camera, turned the lens half way around and repeated the operation. The line found in both ways was coincident. Since that time I have found that a fine thread directly in front of the dry plate holder will be photographed, and I have now arranged two cross wires, one vertical, the other horizontal, that will be photographed in all my subsequent pictures for surveying purposes. With these lines in place and the camera accurately leveled, there will be little chance or opportunity for error, except such as comes from the instrument itself.

MEANS OF LEVELING.

My camera is mounted on a tripod, with leveling screws as used for a Y level. It can be leveled accurately and quickly and will remain where placed. It had a single swing back, but I found it the source of some errors, and, consequently, inserted scews to hold it rigid.

ADJUSTMENTS.

The principal and only adjustment required is that the image of the cross wires, when the instrument is level, shall be in the principal vertical and horizontal planes. The cross wires are best adjusted by an actual trial with objects known to be in the required planes. Once set they will be correct, for the camera is rigid and can not be inverted.

PRINTING PROCESSES.

The negative may be used to measure the angles from by laying the protractor on the glass. It is, however, an inconvenient thing to work from and liable to be broken or scratched. I would recommend some kind of a print.

BLUE PRINTING.

The simplest is the blue print process, and if a first-class special paper, as the Helios, is used, there will be no appreciable shrinkage. This process should be familiar to every one, as it is very convenient to duplicate tracings, and saves in that way untold labor. The chemicals used are—

Red prussiate potash, 1 part,
Citrate of iron and ammonia, $1\frac{1}{4}$ to $1\frac{3}{4}$ parts,
Water, 6 to 8 parts.

These chemicals should be dissolved separately and kept separate until needed. They can then be mixed and applied to the paper with a brush or a sponge. For printing from negatives a better solution will be had by using only about half as much water as given above. The chemicals can be applied by lamp light and the paper dried during the night; it must not be exposed to the light when dry. The writer discovered a queer property of blue print paper,—that if exposed to the light when wet it will turn light instead of dark. It will keep, however, a long time in a dry dark place. Any good linen paper can be used, but the best results are obtained on special paper made for this purpose.

For the purpose of printing, a frame, or some device, is necessary to hold the tracing or negative in close contact with

the sensitive paper. For the use of negatives, printing frames can be bought cheaply, and these would form a good pattern for larger frames for tracings.

Prof. Cleaves, of Cornell University, obtains excellent prints by clamping the sensitive paper and the tracing outside to a thin board. This board by means of a lever is sprung into a convex form with the tracing exposed. This makes a good contact and forms a cheap frame.

SILVER PRINTING PROCESS.

This is very complicated, and details can be had of any photographer; it is in fact the most difficult process in the art of photography. Albumen paper, which is ordinarily used, will shrink some and probably unequally; so it can not be recommended for this purpose. Aristotype paper is better in this respect, but so far as my experience goes, it runs very uneven and results are very uncertain. Arrowroot paper can be made nearly as readily as blue print paper, especially if one possesses a silver bath. It prints very quickly, gives detail without gloss, and is a rich dark brown, even if not toned. I have had good success with this paper, and give the method of preparing.

The formula I have tried is as follows:—

$3\frac{1}{2}$ parts arrowroot,
2 parts common salt,
100 parts of water.

The arrowroot is first dampened with water and mixed to break up lumps, then add remaining portion of water in a boiling condition. Dissolve the salt at any time.

To sensitize this, float on a silver bath, not to exceed $1\frac{1}{2}$ minutes; a longer time will make the print gray. Fume with strong ammonia for 8 minntes, directly before printing; this will have the effect of making the prints bright, and darker.

Prints are made from this paper as from blue prints; it requires about 8 minutes exposure. They are then washed, toned and fixed as silver prints. The fixing bath consists of six parts of water and one part of hyposulphite of soda.

I feel that I have as fully described the process as the limits of this paper will permit, and with a few practical suggestions I will close. First, in regard to the size of camera. I purchased an 8x10 size, and I have found except for a few cases that a smaller size, for instance 5x8, would answer equally well. A plate 8 inches across is not much smaller than one 10 inches. Second, in regard to the kind of lens. I am fully satisfied that for this purpose, a lens of the wide

angled variety, rather than of the rapid rectilinear, is to be selected. You will need an excellent lens, aplanatic, one that is free from aberration, and the focal length ought to be nearly equal to the longest dimension of the plate. That is for a 5x8 plate use a lens with 8-inch focal distance; with an 8x10 plate use a lens with 10-inch focal distance. In either case the tangent of one-half the extreme angle covered by your plate will be .5, and the resulting angle = 54° nearly. So that in such a case the smaller plate covers the same field as the larger one, but the picture is to a smaller scale. The difference is in favor of the smaller plate for most work, because the instrument is more portable, more readily handled, and much cheaper in first cost.

In the wide angle type of cameras the diaphragms are of the rotating type and are fastened in the lens; consequently they are always in place and can never be lost.

A lens that covers 54° as an extreme angle will do accurate work probably over 45°, so that 8 views would be necessary to complete the horizon or to make a complete circuit of 360°. Usually two views will be all that is required at a station, as angles that on measure seldom exceed 90°.

The cost of a 5x8 photo-surveying outfit will be about as follows:—

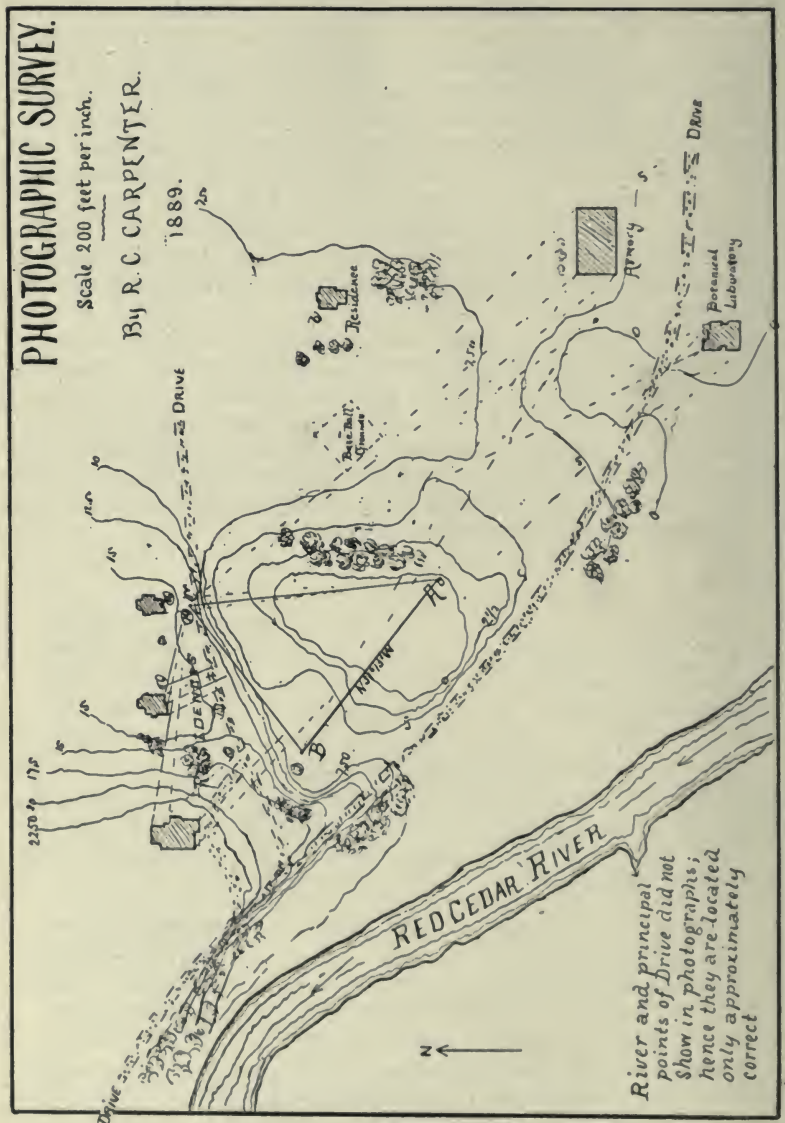
Lens,	$20.00 to $40.00
Camera (no swing back),	5.00 to 15.00
6 Double Plate Holders,	9.00 to 12.00
2 Printing Frames,	1.00 to 1.00
Developing Trays,	1.00 to 1.00
Total,	$36.00 to $69.00

The above does not include a special tripod such as would be needed for surveying, nor does it include apparatus for silver printing. Sensitive dry plates 5x8 cost $1.25 per dozen.

The cost of an 8x10 outfit, suitable for photo-surveying, will be as follows:—

Camera,	$ 8.00 to $25.00
Lens,	30.00 to 50.00
6 Double Plate Holders,	10.00 to 12-00
2 Printing Frames,	2.00 to 2.00
Developing Trays,	2.00 to 2.00
Total,	$52.00 to $91.00

This does not include tripod, nor silver-printing outfit. Sensitive dry plates 8x10 cost $2.40 per dozen.


PHOTOGRAPHIC SURVEY.
Scale 200 feet per inch.
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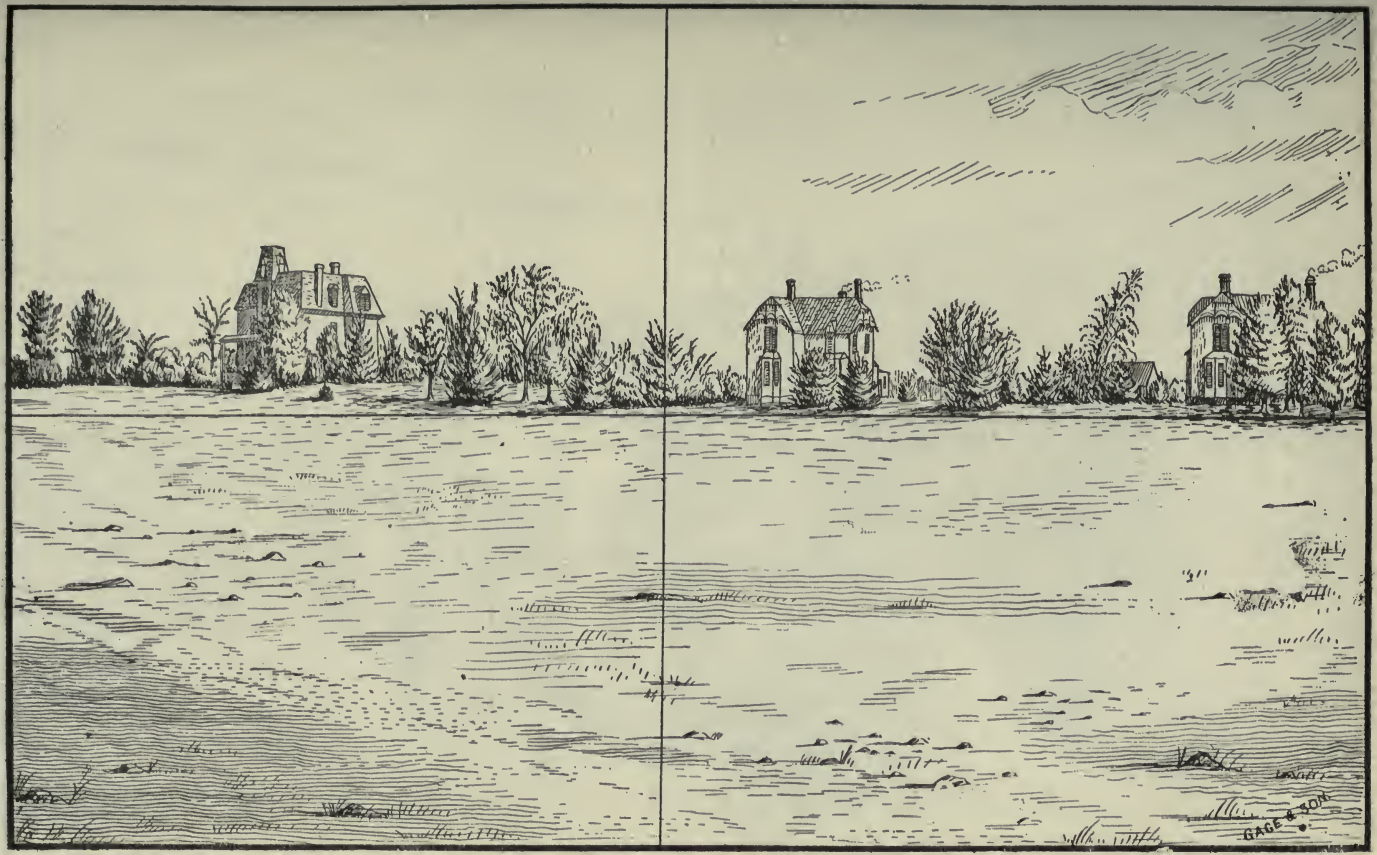
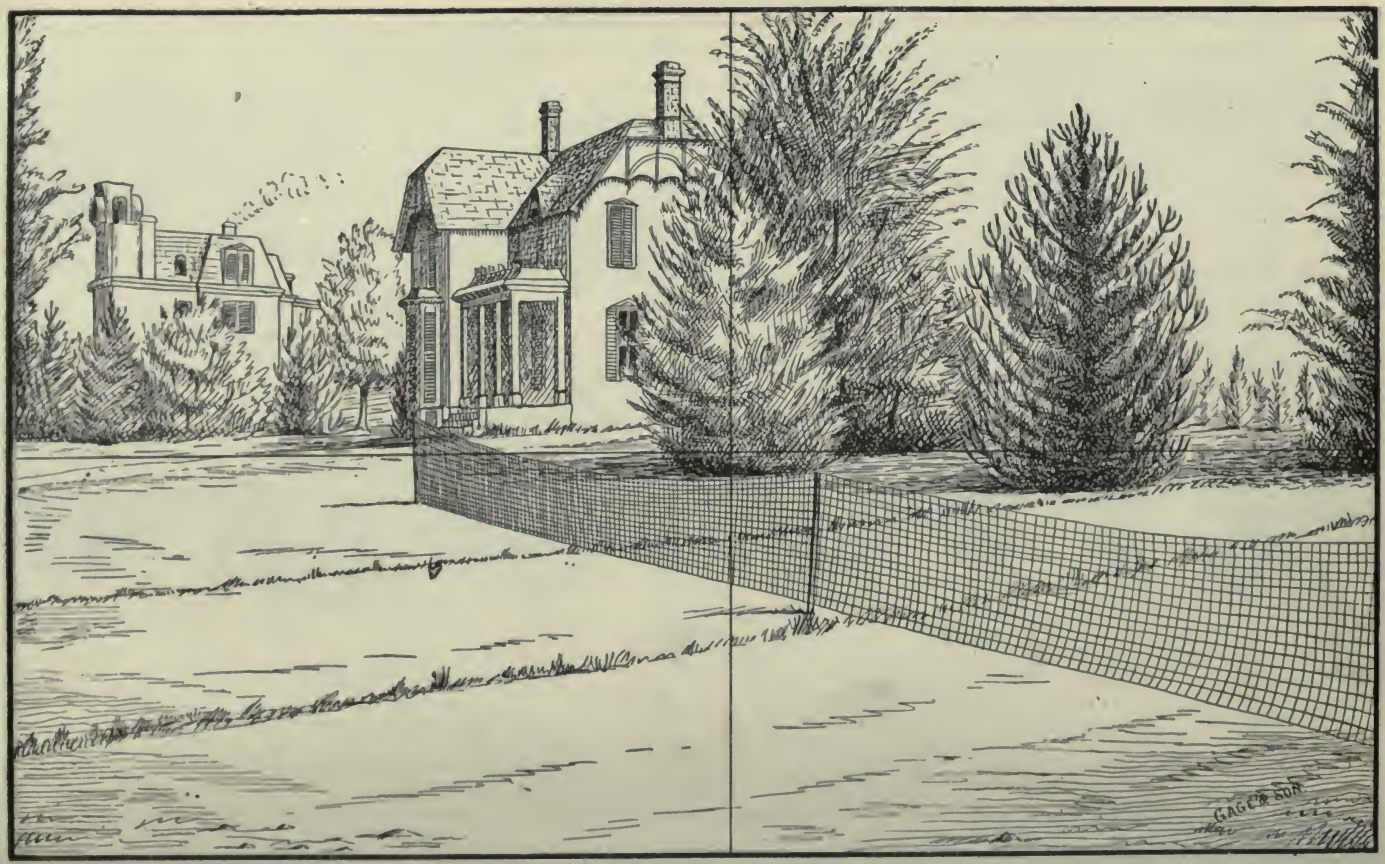
1889.
Residence
Base Ball Ground
Railway
Botanical Laboratory
Drive
REDCEDAR RIVER
N
River and principal points of Drive did not show in photographs; hence they are located only approximately correct


GAGE & SON


GAGE & SON

The map which is presented with the article was worked up as follows:—

The distance from *A* to *B* was accurately measured with a steel tape and its bearing taken with a compass. The camera was then located at *A*, a station was established at *C*, and a photograph taken which includes both *B* and *C*. The camera was then moved to *B*, the other extremity of the base line. In order to include both *A* and *C* it was necessary to take two views, one view including station *A*, and the residence shown to the east side of the map, the second view, showing the same residence and station *C*. The instrument was then moved to *C*, and three views taken, one to the west, one to the north-west and one to the south-east. From the intersection of lines taken from these various photographs the accompanying map was drawn.

The writer regrets very much that time did not permit the production of a much more elaborate map. It will, I think, show the possibilities of photographic surveying. Two of the six photographs from which the map was constructed are reproduced; viz., the view from *A* including both *B* and *C*, and the view from *C* westward, showing intersecting lines.

R. C. CARPENTER.

In connection with Prof. Carpenter's paper, Mr. C. A. Stacey made an exhibit of the photographic stock manufactured and sold by the Eastman Company, of Rochester, N. Y., and demonstrated the manner of use. Mr. Stacey showed the workings of the Eastman system of film photography, by making a negative of the members in a group on a $6\frac{1}{2}$x$8\frac{1}{2}$ transparent film, which was developed on the spot. The developer formula used was as follows:—

No. 1.—*Pyrogallic Acid Solution.*—Pyrogallic acid, $\frac{1}{4}$ ounce nitrous or sulphuric acid, 10 minims; water, 16 ounces.

No. 2.—*Soda Solution.*—Sulphite soda (crystals), 3 ounces; carbonate soda (crystals), 2 ounces; water, 16 ounces.

To develop, take No. 1, 1 ounce; No. 2, 1 ounce; water, 2 ounces.

Fixing Solution.—Hyposulphite soda, 4 ounces; water, 16 ounces.

Mr. Stacey made several demonstrations with flash light and the "quick" bromide printing paper.

The Kodaks were placed in position (several sizes being used) and groups made by use of the flash light. The plates

or transparent film were cut from the roll holder and developed, and passed around among the audience.

The No. 4 Kodak, for 4x5 square pictures, has two finders, one for vertical and one for horizontal pictures, and a fine lens, made by Bausch & Lomb. This Kodak has an instantaneous shutter, which can be set for time exposures; also having rotating stops and adjustable shutter tension, two sockets for tripod screws, rack and pinion for focusing, and when it is loaded, weighing only four and one-half pounds.

The No. 3, for $3\frac{1}{4}$x$4\frac{1}{4}$ pictures, when loaded, weighs four pounds.

At the last evening session, printing and developing the "quick" printing bromide paper was done, making prints from the film negatives of the members which were made at other sessions, so that all could see the workings complete. The printing was done by electric light, also by daylight in a few seconds exposure.

We give below the formula for working the bromide paper.

The requisites for working bromide copying paper for copying drawings or plans, or making photographic copies of any suitable objects, are as follows:—

1 printing frame, of the required size, with glass.
1 glass graduate.
1 minim glass.
2 japanned trays.
1 pound oxalate potash.
1 pound proto-sulphate of iron.
1 pound hyposulphite of soda.
1 ounce bromide potassium.
$\frac{1}{4}$ pound citric acid.

Suitable bottles for contaning the solutions, and a supply of yellow post office paper.

DIRECTIONS.

No. 1.—Dissolve the $\frac{1}{4}$ pound citric acid in 1 quart cold water.

No. 2.—Dissolve the 1 pound oxalate potash in 3 pints hot water.

No. 3.—Dissolve the 1 pound proto-sulphate iron in 1 quart hot water.

No. 4.—Dissolve the 1 pound hyposulphite soda in 5 pints cold water.

No. 5.—Dissolve the 1 ounce bromide potash in 1 quart cold water.

Add to the oxalate of potash solution two ounces of the citric acid solution, and to the iron solution one ounce of the citric acid solution.

All the above solutions keep indefinitely.

Light for Operating.—Bromide copying paper is very sensitive to all white light, whether natural or artificial, and it is owing to this fact that it can be used for making photographic copies of any kind in a few seconds, by either daylight or lamplight.

To prevent the premature action of the light, it must be manipulated only in yellow or red light, to which it is practically insensitive.

To obtain such a light all that is necessary is to fit into the window of the operating room a cloth screen covered with yellow post office paper, or if the operations are to be conducted at night, a truncated cone formed of the same paper and placed over a lamp on the table will give the proper quality of light to operate by. The opening in the top of the cone should be just large enough to permit the heat to escape without scorching the paper.

To Make the Exposure.—We will suppose that the operator wishes to make a copy of a drawing or tracing, and that he is working by lamplight. Proceed as follows: Lay the drawing, face up, on the glass in the printing frame, and after putting the yellow cone over the light, open a package of the bromide copying paper and take out one sheet; lay it face down upon the drawing in the frame, fasten in the back and stand the frame in front of, and say fifteen inches away from the light, so it will fall evenly upon the glass, then raise the yellow paper cone and let the white light shine directly upon the drawing behind the glass. The proper time of the exposure depends upon the intensity of the light, the opacity of the drawing and the distance between the light and the printing frame. Working under the same general conditions, the operator will soon learn to judge accurately of the time required, but in the first instance it will have to be determined by experiment. The quickest way to arrive at the desired point is to partially cover the frame with a piece of card-board and make the exposure in sections, each one having a different period of time.

If the light is from an ordinary No. 2 kerosene burner and the drawing is on white bristol-board, with a distance of fifteen inches between the light and the printing frame, the exposure would be, say two minutes. For a trial give the first section exposed one minute, then draw the card to expose still more

of the drawing, and give one minute more, draw it still further and give another minute, and finally remove the card and give still another minute. The drawing will thus have been exposed in four sections, having respectively four, three, two and one minute exposures.

Replace the paper cone over the lamp, and taking the sheet of bromide copying paper from the frame, lay it in a tray and cover it with clean, cold water; while it is soaking prepare the developer.

The image formed by the light is invisible on the paper when taken from the frame, and has to be brought out by chemicals, called the developer.

THE DEVELOPER.

Take of the solutions prepared as before described, as follows:—

No. 2, oxalate potash solution, - -	3 ounces.
No. 3, proto-sulphate of iron solution, -	½ ounce.
No. 4, bromide potassium solution, -	1 dram.

Mix in the order given, and after pouring off the water from the paper in the tray, pour on the above. In about half a minute the paper will begin to turn dark where the light struck through the drawing paper, leaving the portions protected by the black lines white, thus producing white lines upon a black ground. When the exposure has been correct the lines will be pure white and the ground pure black. The developer should be allowed to act until the parts acted upon by the light are a deep black, then pour off the developer, and pour on, say one ounce of the citric acid solution. After allowing it to act a minute rinse the paper two or three times in pure water and then transfer it to a second tray in which there is sufficient of the hypo-sulphite of soda solution to cover it well; this is called the *fixing solution*, and it removes all the silver not blackened by the developer. After allowing it to act about five minutes return it to the first tray and wash it well for ten or fifteen minutes in running water, then pin it up to dry.

The Drawing.—To produce a good copy the *lines* of the drawing must be *strong and black*, so that when held up to the light no rays will pass through them. If the lines are black a good copy can be obtained from any drawing, whether on the thinnest tracing paper or the heaviest manilla. The only difference being the time required to print.

Uniform Illumination.—When printing by artificial light the distance between the frame and the light should be at least equal to the length of the frame to insure an even illumination.

To Make Non-reversed Copies, the *back* of the bromide copying paper should be laid against the face of the drawing. When making exposure for non-reversed copies hold the frame as far as convenient from the light to get the rays as near parallel as possible; this will increase the time of exposure as the square of the distance. Allowance should also be made for the fact that the light must pass through both the drawing and the bromide copying paper. For instance, say we have to copy a patent-office drawing on heavy white bristol-board. The time of exposure, if the drawing and bromide copying paper are face to face (making a reversed copy), will be about two minutes, fifteen inches from a No. 2 kerosene burner. If the back of the paper is laid against the drawing, the exposure at same distance will be one-half greater, viz: three minutes, while if the distance is increased to two feet to get a sharper image, the time will be eight minutes.

Daylight.—If the exposure is made by daylight the time will be much less, not more than one-fifth to one-twentieth, if made in front of an open window. In exposing by daylight care should be taken to avoid over exposure, by using a piece of straw board so as to cover and uncover the frame quickly.

Negatives and Positives.—A contact print from a drawing will be a negative, that is, the lines will be white and the ground black; if the negative is used to make a second print it will produce a positive or *fac simile* of the original. It is not necessary to dry the negative before making the positive. The piece of bromide copying paper for the positive should be soaked in water and laid, back down, upon a piece of glass or hard rubber, then lay upon it, face down, the wet negative and press them firmly into contact with a rubber squeegee, expose, separate and finally develop the positive as above directed. Negatives should have full exposure and long development to get as much density as possible, so that the positive will show a pure white ground with black lines.

Bromide Copying Paper may be used for copying plans, drawings, letters, documents, or printed matter of any kind by contact, when the matter to be copied is on one side only of the original. It can be used for making copies of leaves, dried or undried, for botanists' use. It can be furnished in rolls of any length or width for recording instruments in astronomical observations, etc., and it is available for many

other purposes where a sensitive paper that will keep both before and after exposure is desirable.

Hypo. Stains.—The hyposulphite of soda solution, if allowed to mix with any of the other solutions, will cause irregular black markings. The hands must be well rinsed after using it, to avoid stains on the paper.

Blisters sometimes appear in bromide paper, and may be avoided by using a little common salt in the first water after fixing. Dissolve two tablespoonfuls common salt in one pint water ; put the print into this as soon as it comes out of the fixing solution ; allow it to act one minute, then wash and dry.

ADVANTAGES OF BROMIDE COPYING PAPER FOR COPYING DRAWINGS.

1. *Rapidity of Execution.*—Prints in one two-hundredth of the time required for the blue process ; can be printed by the light of an ordinary lamp.

2. *Color.*—Pure blacks and whites by development. No toning required.

Copies of Drawings to Accompany Estimates should always be made on bromide copying paper, thus retaining all the good quality of the originals without the cheap look of blue prints.

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THE PLANE TABLE.

THIS is a surveying instrument in use for obtaining the very last details, and for topographical work. It is not very accurate, but will give uniform results, so that if the scale is small, or the results are not needed with too much accuracy, it answers a very good purpose. Years ago it was in use on the U. S. Lake Survey, but was abandoned and a transit and drawing board taken into the field in its stead, I believe. This was because the men on the survey were not pleased with the trustworthiness of the results obtained. As you are aware, this instrument consists of a drawing board mounted on suitable devices for putting and keeping it level. On this board is stretched a piece of paper, and a map of the work is carried forward as the work progresses. In connection with the plane table there is always used an alidade. This alidade is nothing but a rule or straight edge, and a line of sight. The line of sight may be the edge of the rule, or be defined by a pair of compass sights or a telescope. All that is necessary concerning this line of sight is that it should range in a plane perpendicular to the under side of the rule. In order to make the adjustment easy it is customary to make this line of sight range, or revolve, in a plane parallel to the edge of the rule, as well as perpendicular to its under side. It seems as though the plane table would solve some problems not possible with the transit, because of the map being combined with the instrument, but such is not the case. One of the more notorious of these problems is the Two-Point Problem of the books. This can be solved by the transit as well as with the plane table.

I shall be more particular to mention those things not to be found in books. By the books one is instructed to set the plat of a point on the table over the point on the ground which it represents. There is provided and sold a sort of a U for the purpose of plumbing down from the point on the table to the point on the ground. But with the aid of all the devices to be obtained it will be a mere chance if when the table is set the point on it is over the point on the ground which it represents. The reason of this is that the table must be set always parallel to its first position on the survey, and so it occurs that when it is set so the point on it is over the point on the ground which it represents, the first thing to be done is to turn it slightly from this position in order to orient the table, that is, set it parallel to its first position, and so destroy the relation of the two points which was so carefully obtained. This is to be considered a vital defect in the use of the plane

table and no doubt it has led to the abandonment of its use in numerous instances. This defect I remedied some fifteen years ago or more by setting the table central over the point of observation with a plumb bob just as a transit is set. I find by reference to my class records that I was giving instruction in this manner of using the plane table in 1875. There are required for use with the plane table when operated in this manner two triangles. These are carried instead of the U-shaped tool before named. The plumb bob is hung at the center of the instrument as in any case. It is also necessary to find the center of the sheet of paper on the drawing board, that is where the spindle axis of the board will pierce the paper. This may be very easily done for each sheet of paper but a much better way is to do as follows: Fix some sharp pointed tool, like a knife or a needle point rigidly, so it will barely scratch a fine mark on the face of the board when it is turned on its spindle under this fixed point. By these means scratch the circumference of a circle, or parts of one, on the face of the board. Make sure it is nicely and precisely done. Construct the center of this circle. It will be the center of the board as above described. Set in a piece of brass flush with the face of the board so that a hole in it of a suitable size to admit a common pin will mark the center permanently. Whenever a new paper is put on the board a little search will enable a pin to be pushed through the paper into the hole in the brass where it should fit and be left standing for convenience in using the board. By this arrangement the alidade, which, as usually constructed, is of considerable weight, will always stand central on the board and not near its edge. This will give increased steadiness and stability. To illustrate the manner of using the plane table in this case I will describe a few of the operations necessary to start a survey, well knowing that when that is done the work can be followed out readily. Take the plane table to the first point of the survey or to the place where it is to begin. Set it over the point just as a transit would be set with the plumb bob from its center and over the point. Observe to set the table so low that the edge of it will come at the bend of the body just below the hips of the person who uses it. This is necessary to make the working of the table convenient and to prevent liability of resting the weight of the arms or some part of the body on the table, which must not be done. All beginners are apt to set the table far too high. Next clamp the spindle of the table so it will stand in a position suitable for receiving the work to go on it with reference to the point it stands at, remembering that

always after this it must be set parallel to this, its first position. Place the alidade central on the table with its level tubes parallel to the pairs of leveling screws below. Carefully level the table. It is now ready for use. To begin observations to other points of the work, first choose which hand the rule of the alidade is to be used on, that is make a choice of which side of the lines observed along, with references to the observer, either to his right or to his left, the rule shall be set. Having made this choice it must be continued throughout the work, to avoid introducing the errors of some of the adjustments into the work. It is well for a right-handed person to use the rule on his left of the lines and on the right for a left-handed person. This must be continued to be done when looking along any line in either direction. Having made this choice, place the work edge of the rule of the alidade gently against the pin in the centre of the sheet, and with the hands, sliding the alidade on the paper but always keeping it up to the pin as noted, bring the line of sight on to the line to be observed and leave it carefully set there. Choose the place on the paper where the plat of the first point of the survey shall be and prick it down with a needle point or note it precisely in some way. Place one of the triangles against the rule and the other triangle against the first named so the first named can be slid over the paper and have its edge that was placed against the rule pass through the chosen point. Make the transfer of the line from the rule to the point and draw the line on the paper through the point. Slide the triangle back to the rule and make sure there are no slips. See if the line of sight still stands on the line it was set on. If these checks show errors, review the operations and correct them. These operations can be repeated for any number of points or lines. Finally before taking the plane table to a new place, try the position of the table by the first line laid down on it. To do this, set a triangle to this first line as it is drawn on the paper and slide it over to the center of the sheet. Grasp the alidade firmly and set it by the edge of the triangle at the center of the sheet so it—the rule—will still stand parallel to the line. See if the line of sight strikes the first line of observation. It may not fit with great precision,—this is not to be expected,— but a little experience will show when it will be necessary to review the work. By these means make sure of the stability of the table during the observations. Having done this the table may be carried to the next point of the survey and set up and leveled as before, except now there will be no use in trying to set it by estimation in position

only in a general way. After it is leveled, slide the line from the plat of the point at which the table stands to the plat of the point from which it came, over to the center of the sheet and set the alidade by it as before described for testing the stability of the table at the last point. Be sure to keep the rule on the *same hand of the observer*, *not* on the same side of the line. Having set the alidade as above noted, slide the triangle back to the line and see there are no slips. By means of the clamp and slow-motion screw to the spindle, set the line of sight on the point from which the table came. Now, the table is said to be oriented, that is, it stands parallel to its first position. Observations may now be made as at first. They may be continued at will, but observe to test the stability of the table, and the quality or correctness of the work and the various observations connected with it so frequently that the result obtained may always be received with confidence that they are as good as the plane table will give.

For the methods of determining the positions of points, and the various plans of conducting a survey, the text books on surveying may be consulted. For this purpose see Gillespie, new edition. Johnson gives a little about the plane table, but there is a more complete work entitled The Plane Table, from the papers of the U. S. Coast Survey. No trouble will be found in adapting the processes given in these books to the method of setting the center of the board over the point of observation in the regular way of using other instruments, and better results will be got with greater ease, comfort and speed.

With the plane table goes its plumb bob, the alidade, the triangles, a scale, three-legged dividers for transferring points, hard pencils, erasers, pocket knife, thumb-tacks in plenty, a little compass box made for this especial service (sometimes this is on the rule, but better be separate), and a large piece of rubber sheeting or light rubber cloth of a size to envelop the table and all there is on it, and tack under the board, to secure the drawing and the various things from the rain or dust as occasion may require. There may be a place made under the board to keep the triangles, the scale and some of these things in.

The telescope on the alidade may have a vertical circle, a level on the telescope tube, and be fitted with stadia cross wires. These devices are all well described in books, and will be found of service in much plane table work. The stadia may be used for measuring heights and distances roughly for topography. The distances in good stadia work compare well

in precision with the common chaining before the day of the steel tape. Hence it is quite good enough for topography. I mention these things to call attention to the fact that the stadia will measure a designated distance, and, with the vertical circle, a designated height and distance, but that it cannot be used to set out, lay off, or measure, a given height or distance,—as 745.14 feet. It solves but half the problem. This is the simple—and sufficient—reason why it has never come into more general use. No one should attempt to lay out work with a stadia, unless ready to part with his eyes, as all experiences of this kind, within my knowledge, show that this will be the result very shortly. The stadia is so frequently used with the plane table that I deem this word of caution necessary.

The determination of the sides and angles of a triangle with a plane table presents all the difficulties or peculiarities of plane table work, except in one case, that of determining a fourth point from three others, known as the three point problem. What appear in the books to be more than this really are not. The three-point problem having been much discussed and elaborated, especially in former times, I will suggest still another solution of it that will be found convenient for use on the plane table. This solution is entirely mechanical and requires no rules, or equations, or geometry. This is the three-point problem: Knowing the location of three points, that is they are platted down on the plane table, the position of a fourth point may be determined by setting an instrument at this fourth point and observing the angles between lines from it to the three given points. To do this, set the plane table at the fourth point, without attempting to orient it, dampen it, and draw three lines by the rule from the center of the sheet running to the three given points. An extra piece of paper may be put on over the sheet if desired for this purpose. Fit the three-legged dividers with one foot on the plat of each one of the three given points. Notice which way from the three given points on the ground the fourth point, at which the table stands, is. Fit the three-legged dividers, carefully set as above noted, on to the three lines drawn toward the three points from the center of the sheet, so the center of the sheet, which represents the fourth point, will be in its relative position with respect to the three feet of the dividers. Make the adjustment with precision. Now prick down the three points on the three lines, and these, with the center of the sheet, will show the relative position of the four points on the ground to the scale used. Set the

three-legged dividers on two of these and the center of the sheet. Place the two feet on the plats of these two points on the map and prick down the plat of the fourth point with the third leg. It may, of course, happen that the plats of the three given points cannot be spanned with the three-legged dividers. This is easily met by reducing the distance between them by the same ratio, and thus obtaining three points the dividers will span. Then solve the problem with these three, and the resulting four point figure will be too small by just the ratio of reduction used.

For all such work a pair of three-legged dividers of considerable size is needed, having the third leg sliding in a sleeve with a clamp, so it can be set at any length within the limits of the piece.

I solved the problem in this way at about the time mentioned above as the time when I began working from the center of the sheet. There are six possible solutions. Three of these are easily traced out by trying the experiment. The other three might be missed, and are to be found by turning over the paper on which the three lines are drawn, and applying the dividers to the back side of the paper. I also tested the solution in the special cases, and when the four points are on the circumference of a circle. I examined all these results to see if there was anything in them likely to confuse the operator. There was not. Be sure to notice which way from the three given points the fourth one is, and apply the dividers to the three lines accordingly. That is all.

The ordinary problems in surveying I solved many years ago with the plane table. Some of these are laying out circular curves, parabolic curves, finding the azimuth of a line astronomically, and the like. But these things are of the nature of curiosities or extreme exceptions, and are much better done with other instruments.

In taking charge of any instrument for the first time, look over even the simplest matters, and see that everything is in order from the ground up. From that on, these matters constitute a part of the operator's general care. This is especially true of the plane table. See that the shoes at the bottoms of the tripod legs are tight, and do not rattle. See that the legs work tight enough at the cap. See to the tripod head and its connection with the board. See that the arms under the board are tight fast to it; that the board itself is flat and square to the spindle. See that the rule is straight, and the two edges of it parallel, so one may slide off lines from either edge.

Plane tables are sold from $150 to $350. The great point to be considered is steadiness of the table. I have never been informed why these instruments are charged for at the rate they are. The prices seem very high to me. The board should be of dry, soft, even, straight grained pine. The same defects of construction attend these instruments that do others. The clamp on the vertical circle is bad, and many other similar defects are to be found.

I will conclude by giving, in a compact form, the adjustments of the plane table.

1. See that the edge of the rule is straight by testing it on a fine pencil line, and correct it if need be. Also see that the two edges of the rule are parallel by drawing fine lines by each edge, and testing them with the dividers.

2. See that the surface of the board is a plane, by testing it in all directions with a straight edge, and working it down, if need be, with a smooth plane, a scraper, or sand paper.

3. Levels on the rule.

Set up the board and level it.

Draw a line by the edge of the rule, and mark the place of the ends of the rule.

Remove the alidade and replace it on the board on the opposite side of the line, just fitted to it, and the ends of the rule at their marks.

See if the bubbles show level.

If not, reverse the alidade back again and make a few reversions till satisfied the bubble tubes are out of adjustment.

Leave the alidade so as to show the error.

Correct one-half the apparent error by means of the screws that hold the tubes to the rule.

Test the adjustment as at first.

Repeat the tests, corrections and tests till no error appears.

4. Board square to spindle.

Set the plane table and level it with the alidade central.

Reverse the table on its spindle.

See if the bubbles still read level.

If not, reverse back, and by repeated reversions make sure if any error exists.

Leave the table so as to show the error.

Correct one-half the apparent error by inserting wedges between the arms and the board, beneath it.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

Having the board thus properly set, replace the wedges by suitable washers or other devices of a permanent and durable kind, and finally fit these so that the above described test shows no error.

5. Line of sight at right angles to telescope axis.

Set up the table and level it with the alidade central.

Find two points in apparent line and clamp the spindle with the line of sight set on them.

Reverse the telescope carefully on its axis and find a point in apparent line in the opposite direction.

Reverse back again, and by repeated reversions make sure the table and alidade are steady.

Lift up the alidade, change ends with it, and replace it on the table in a reversed position with great care. Set the line of sight on the two first named points, for which purpose the spindle slow-motion screw may be used, if need be.

Reverse the telescope on its axis and see if the third point is in line.

Reverse back again, and by repeated reversions make sure the table and alidade is steady.

Leave the telescope looking at the third point, so as to show the deviation of the line of sight therefrom—or the error.

Correct one-fourth this apparent error by moving the cross-wires by means of the screws that hold them in the telescope tube.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

The above directions apply to a telescope that can be reversed. In case it cannot be reversed, the wyes must open and then the line of sight adjustment be made by pointing on any point; lifting the telescope out of the wyes; turning it over; replacing in wyes, same end towards point; seeing if line of sight now strikes the point; correcting one-half the apparent error by the cross-wire screws, and testing, and correcting and testing till no error appears.

6. Adjusting telescope axis vertically.

This makes the line of sight revolve in a plane, perpendicular to the under side of the rule.

Set up the table as near some high, well-defined, fixed point as it can be, and that point be observed through the telescope with the alidade central on the board. Place the alidade central on the table, and level it carefully.

Set the line of sight on the high, fixed point, by means of the spindle clamp and slow-motion screw.

Turn the objective downwards, till the line of sight points at nearly the same angle below the horizon that it did above. Find or take two points near by in apparent line, ten or fifteen feet apart, with little or no change vertically in the pointing of the telescope.

Make sure of the stability of the telescope, by repeated pointings upon the upper and lower points.

Reverse the alidade and the telescope on its axis. Set the line of sight so as to range upon both lower points, using the spindle clamp and slow-motion screw.

See if the upper point is in apparent line. Repeat the pointings, to make sure of the stability of the telescope. Leave it looking at the upper point, so as to show the error.

Correct one-fourth the apparent error, by means of the device provided for controlling the inclination of the telescope axis to the horizon.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

7. Adjusting the telescope axis, horizontally.

This makes the line of sight revolve in a plane parallel to the edge of the rule.

Provide a firm, level support for the alidade. Two stout, square-topped stakes properly driven may answer. This support may be leveled by the alidade. The cross level is the more important, but both should be level. From this support the line of sight should strike a distant, well-defined, fixed point. Have ready a needle, needle point, or a similar tool. Put a paper on the table.

Set up the table about 20 feet from the alidade support and on line from it to the distant point. Level the table carefully and clamp the spindle securely.

Place the alidade on the prepared support. Set it level by bits of wood, or the like, when its line of sight strikes the distant fixed point.

Locate two points in line on the table with the needle point a little less than the length of the rule apart. Also locate a point in line 40 or 50 feet beyond the table.

Transfer the alidade forward, as it stands, to the table with the edge of the rule at the points located on it.

See if the distant point and the near point are now in the range of the line of sight, or both the same distance therefrom on the same side.

By means of the device for controlling the angle of the telescope axis with the edge of the rule, set this axis so the line of sight will strike the points named, or pass the same distance from and on the same side of both when the alidade sets on the line of the points on the table.

After the adjustment seems perfect see that the table has not been moved, by trying the line of all the points again from the alidade support.

In making this adjustment the alidade may be set over parallel to the line of the two points on the table, by pricking off equal spaces from them, so that, after sufficient trials, the line of sight will strike both points when the telescope axis is adjusted. This saves any estimating of the distances the two forward points are from the range of the line of sight.

8. Center of the board. Given on a previous page in the first part of the description of the use of the plane table.

9. Vernier to vertical circle. Adjusted the same as on a transit instrument.

10. Telescope level tube. Adjusted the same as on a transit instrument.

In the case of the 9th and 10th adjustments the alidade should stand central on the board, and close watch kept and frequent tests applied to be sure of the stability of the apparatus during the work of adjustment. J. B. DAVIS.

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SUPREME COURT DECISIONS.

The following abstract of Supreme Court Decisions rendered during the past year, is taken by permission from the American Digest, published by the West Publishing Co., St. Paul, Minn.:—

1. Where an inland non-navigable lake covers a portion of a section of land, and the Government survey designates the dry land in each subdivision as a fractional subdivision or lot, the purchaser from the Government of such lots acquires title to all that portion of the bed of the lake included in the whole subdivision.—Stoner v. Rice, (Ind.) 22 N. E. 968.

2. Where the patentee of "the north half of the south-east quarter, and that part of the north-east fractional quarter, of section 36," etc., "which lies north of the Kankakee river, containing in all 122.70 acres," conveys "the north-east quarter of section 36," etc., "containing 122.70 acres," the deed passes title to all of the land in said north-east fractional quarter lying south of said river.—Sphung v. Moore, (Ind.) 22 N. E. 319.

3. A patent for a fractional quarter section, which is bounded by a meandered stream, passes title to all land within the lines of said quarter section between the meandered line and the water's edge.—Sphung v. Moore, (Ind.) 22 N. E. 319.

4. Where two deeds in plaintiff's chain of title respectively define the boundary of the land "by the edge of the mill-pond," and as "the bank of said mill-pond," and defendant is entitled to pond as much land as the pond flowed at the time of his purchase, defendant may enter on land originally covered by the pond, but which has subsequently become dry land by the receding of the water, though plaintiff's deed on its face shows his line to be the center of the pond.—Holden v. Chandler, (Vt.) 18 A. 310.

5. The owner of land on a bay conveyed an acre at the end of the tract nearest the bay, described as follows: "Beginning * * * by the beach, running * * * along the beach to," etc. In the general description of the tract it was bounded "easterly by the said beach." The grantee was given the privilege of a road from the middle of the front of the lot to the bay, and also half the drift coming on shore in front of the lot, and all the other privileges of the beach were reserved by the grantor, who bound himself not to build any house in front of the lot. The courses and distances would not carry the boundary to high-water mark. *Held*, that the beach did not pass by the deed.—Benson v. Townsend, 7 N. Y. S. 162.

6. Where a deed conveys land "bounded and described according to" a certain survey, does not call for a river, but calls for a line run between certain points, designated by the surveyor as on the bank of a navigable river, and it appears that the lines of such survey exclude flats between high and low water marks, evidence *aliunde* is admissible that the bank referred to was an artificial dike; that the grantee had notice that the grantors reserved the flats; that the grantors refused to execute a deed expressly conveying the flats; and that the sale was expressly subject to the survey, as tending to show that the flats were excluded, whatever may be the presumption from the deed.—Palmer v. Farrell, (Pa.) 18 A 761.

7. A complaint was filed to quiet title to 150 acres of land lying on the south side of a fractional section. A surveyor was ordered to survey that quantity, to be taken the full length of the section from the east side thereof to a river as the western boundary, and extending far enough north to include 150 acres. The surveyor executed the order, and reported a survey, which was accepted, and the court entered judgment, wherein the land was doubly described by inconsistent descriptions. The first described it as in the order of survey, and the second by metes and bounds, by which, after beginning at the south-east corner of the section, and following the south line to the river, it ran up the river, with the meanders thereof, to a stake placed by said surveyor 19⅓ chains north of the south line of the section; thence running westerly, parallel with the south line, 53.04 chains, to

a stake in the east line of the section; and thence southerly with said line 9⅓ chains, to the beginning. The stakes were gone, but were shown to have been placed at points 19⅓ chains from the south line, thereby including 150 acres. *Held*, that the first description should govern.—Caspar v. Jamison, (Ind.) 21 N. E. 743.

8. Rev. Stat. U. S. § 2396, provides that "the boundaries and contents of the several sections, half sections and quarter sections of the public lands shall be ascertained" as follows: "All the corners marked in the surveys returned by the surveyor general shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate; and the corners of half and quarter sections not marked in the surveys, shall be placed, as nearly as possible, equidistant from those two corners which stand on the same line. * * Boundary lines which have not been actually run and marked, shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships where no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners * * * to the water-course," etc. *Held*, that in surveying a lot bordering on a river the water-course becomes the boundary, and continues so, no matter how much it shifts by accretion, and conveyances of the lot pass all, including such accretion to that line.—East Omaha Land Co. v. Jeffries, 40 F. 386.

9. The facts that rapid changes in the banks of the Missouri river are constantly going on, and that 40 acres have been added to adjoining land, do not overthrow an averment of a bill to quiet title to such addition, on the ground of accretion, that it was by an imperceptible increase, where it was nearly 20 years in forming. —East Omaha Land Co. v. Jeffries, 40 F. 386.

10. Where a deed describes a lot conveyed as of a certain width, and a party-wall stands on the south line, the north line may be found by measuring the given distance north from the middle of such wall.—Warfel v. Knott, (Pa.) 18 A. 390.

11. Where the probate judge, in pursuance of the provisions of Sess. Laws, Colo. 1872, p. 191, relating to town-site lots in Denver, advertises and sells a lot bounded on an unnavigable stream, and on the same day, and as part of the same sale, sells the bed of the same stream to another person; the deeds for the two parcels being executed the same day, and containing the same recitals,—the intention thus shown to separate the ownership of the bed of the stream from the ownership of the lot will overcome the presumption that a deed to a lot bounded on an unnavigable stream carries the title to the bed of the stream to its center.—City of Denver v. Pearce, (Colo.) 22 P. 774.

12. An instruction that, in arriving at a boundary line as originally run, natural objects are controlling calls; artificial objects, second in importance; course, third, and distance, fourth; and that, where there is still uncertainty, that rule should be adopted most consistent with the intent of the grant, is correct. —Luckett v. Scruggs, (Tex.) 11 S. W. 529.

13. An instruction that the beginning corner of a survey is of no higher dignity or importance than any other corner, and that, "if there are well-known and undisputed original corners established upon the ground around the survey, they would control the other calls of the survey, which are conflicting and contradictory, if there are any such," is correct.—Luckett v. Scruggs, (Tex.) 11 S. W. 529.

14. Where neither the corners of plaintiffs' nor defendants' land are satisfactorily established, and there is a well-established and identified corner of another survey, from which, by following course and distance, defendants' survey can be constructed, such course should be followed, though the boundaries thus established include land within the boundaries of plaintiffs' junior survey.—Griffith v. Rife. (Tex.) 12 S. W. 168.

15. Where the beginning corner of a survey is the south-west, but the south-east corner is equally well identified, a charge limiting the jury to finding the unidentified northeast corner by the first and second lines from the south-west

corner, is erroneous, as the south-east corner is of equal importance, unless the line from the former corner was actually run and measured, and that from the latter not.— Scott v. Pettigrew, (Tex.) 12 S. W. 161; Lancaster v. Ayres, Id. 163.

16. An instruction making the importance of an established north-east corner, in locating the north and west lines of a survey, dependent upon the jury's belief that such western line was not run, is erroneous, as such corner has the same weight for the purpose in question, whether the western line was run or not.— Scott v. Pettigrew, (Tex.) 12 S. W. 161.

17. In the description of lands, as to questions of boundaries the rule is settled in Virginia and West Virginia that natural land-marks, marked lines, and reputed boundaries will control mere courses and distances, or mistaken descriptions in surveys and conveyances.—Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

18. The statement of the quantity of land supposed to be conveyed, and inserted in deeds by way of description, must not only yield to natural land-marks and marked lines, but also to descriptions in deeds by courses and distances.— Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

19. A call for a lot by the name or number which it bears on a plat of the land will prevail over courses and distances, and ordinarily over calls for monuments.— O'Herrin v. Brooks, (Miss.) 6 So. 844.

20. Where the descriptions in a deed refer to a survey and a map based thereon, making both a part of the deed, and there is a discrepancy between the map and the survey, the latter will prevail.—Whiting v. Gardner, (Cal.) 32 P. 71.

21. When a survey calls for the "Dougherty" survey as one of its adjoiners, an instruction that if the jury find that the "King" is the survey intended by the call for "Dougherty," the former being located, the call would furnish "some evidence" of the location of the survey in question, is insufficient, as such a finding would locate the survey in the absence of marks upon the ground.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

22. Where no marks are found on the boundaries of a survey, and it cannot be located on the ground, evidence of the location of junior surveys which call for the lines of the elder as adjoiners is admissible, as showing where the surveyors upon the ground located such lines.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

23. Where the court, in an action of ejectment, instructs the jury that, "after a survey of blocks had been returned and had remained in the land-office 21 years, it was conclusively presumed that it was run upon the ground, whether marks were found upon the ground or not," but in other portions of his charge repeatedly states the law to be that marks made by the surveyor on the ground are the first and highest evidence of the true survey, the instruction cannot, on the whole, be said to be misleading, as he will be reasonably understood to have charged that the presumption in favor of returns of surveys on file for 21 years is only applicable to such surveys where no monuments or marks on the ground are found to contradict them.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

24. The monuments or marks of the surveyor on the ground determine the true survey as against calls for adjoinders or courses and distances as returned; but, each block of surveys being separate and complete of itself, the call of a tract in one block for an adjoinder in another does not make the monument of the adjoinder the monument of the later block.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

25. Where a boundary line is assented to by the owner of a tract of land at a time when there is no dispute concerning such line, and on the supposition that it is the true boundary, he is not estopped, on discovering that such is not the case, from claiming title to the real boundary.—Schraeder Min. & Manuf'g Co. v. Packer, 9 S. Ct. 385.

26. Continuous and uninterrupted possession, under claim of ownership, to the line of a division fence, will not bar title, where it appears that such occupa-

tion was under a belief that the fence was on a true line, and without intention of claiming beyond the true line, as described in the deeds.—Skinker v. Haagsma, (Mo.) 12 S. W. 659.

27. Where a survey is referred to in a deed for greater certainty, it legally forms a part of it and both should be construed together.—Heffleman v. Otsego Water-Power Co., (Mich.) 43 N. W. 1096.

28. An exception in a deed which reads, "Except the dower of fifty acres, as fully described in the deed given the C. B. Co.," is not void, though the boundaries of the excepted land are not defined in any way, as reference may be had to the deed to the C. B. Co. to ascertain them.—McAffee v. Arline, (Ga.) 10 S. E. 441.

29. The exterior of two adjoining interior surveys were undisputed. The boundary line between them had never been surveyed, but its southern end was marked by an oak. North of these surveys were two others. These four surveys were originally returned as being of equal size, and having one common corner. The northern end of the line between these two latter surveys was marked by a sugar-maple; which was not directly opposite the oak, and it was proved that the northern line of these surveys was shorter than the southern line of the others. *Held*, that the boundary line between the two southern surveys should run from the oak parallel to the end lines, and not diagonally from the oak to the maple. —Bloom v. Ferguson, (Pa.) 18 A. 488.

30. The course of the eastern line of the H. tract, as given in the original survey made in 1745, was 14 deg. east. The course of the western line of the B. tract, lying immediately east of the H. tract, as given in the original survey made in 1813, was 17 deg. and 15 min. east. The western line of the B. tract was made of exactly the same length as the eastern line of the H. tract, and the beginning point of the two lines was the same. The difference in the course of the two lines could be satisfactorily explained by the change in the position of the magnetic needle which had taken place in the time intervening between 1745 and 1813. *Held*, that the two lines must be considered as coincident.—Scott v. Yard, (N. J.) 18 A. 359.

31. The owner of a lot in the city of Rochester, of the area of about one-half acre, rectangular in form, fronting 274 feet on a street, and abutting on the rear for the same distance on a canal, the location of both, as well as the other lines, being undisputed, conveyed a portion, by description, of "137 feet front and rear, measuring from G. H.'s north line on G. street, and also 137 feet from G. H.'s south line on the canal; being the piece of land occupied as a garden by the grantor." The lot was divided by a fence, one side being used as a garden; the fence starting on G. street midway, but striking the back line at the canal at a point 19½ feet from the middle of the lot. That fence was not mentioned in the deed. *Held*, that the reference to the garden was too indefinite to control the calls for exact distances from known bounds, and the divisional point on the canal should be located 137 feet from G. H.'s line.—Harris v. Oakley, 7 N. Y. S. 232.

32. Plaintiff owned a village lot, No. 124, and a tract of land lying adjacent thereto on the south and east sides. River street, which lay along a river's edge, was the westerly front of both the lot and the tract. He conveyed the tract to defendant, reserving a part thereof, beginning at the S. W. corner of the lot; thence south-easterly, along River street, 32 feet; thence north-easterly, "on a line with the S. E. corner of lot No. 124," 10 rods and 23 links; thence N., to M. street; thence W. to the N. E. corner of the lot; thence south-westerly, to the S. E. corner; thence to the beginning. Locating the beginning point at the S. W. corner of the lot as appeared by the village plat on the easterly side of the street, the line passed directly through the S. E. corner of lot 124, taking no part of the lot, and thus making the reservation wholly within the tract conveyed; but by beginning at the river's edge, on the westerly side of the street, on the theory that plaintiff's property extended to the river, subject only to the easement of the street, the line would pass through and take part of lot 124. *Held*, that the former location of the corner was correct.—Anderson v. Scott, (Mich.) 42 N. W. 991.

33. Lands are not surveyed lands by the United States until a certified copy of the official plat of survey has been filed in the local land office.—United States v. Curtner, 38 F. I.

34. A county surveyor, employed to restore the lines and corners of adjoining tracts of land according to the original government survey, found township corners only, then (the other quarter and section corners being missing) ran a straight line from one township corner to the other, and on this line placed the quarter and section corners, but did not take any testimony to ascertain the lines or corners of the original survey, did not attempt to prove his lines or corners by re-establishing the missing corners from all the nearest known original corners, in all directions, did not sufficiently regard the field notes, and did not, where the original monuments had disappeared, regard the boundary lines long recognized and acquiesced in. *Held*, that such a survey is incomplete, and cannot be approved as the true and correct determination of the boundaries and corners as originally established by the Government.—Reinert v. Brunt, (Kan.) 21 P. 807.

35. Upon an issue as to the location of a line of the Government survey, evidence of the location of monuments is not overcome by field-notes of the original survey, taken at the time of the erection of said monuments or subsequent thereto.—Hubbard v. Dusy, (Cal.) 22 P. 214.

36. As between complicated descriptions of a line dividing two sections or quarter sections, that one is to be adopted which is most in conformity with the monument established by the Government survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

37. As between different monuments, those best identified should prevail, independent of anything in the field-notes of the original or any subsequent survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

38. Where it is doubtful which of two lines of monuments is the true Government line, other things being equal, that one is to be so considered which most nearly conforms to the field-notes.—Hubbard v. Dusy, (Cal.) 22 P. 214.

39. Testimony of declarations of a grantor, before the execution of a deed, tending to establish a boundary other than that made by the deed as construed by the court on appeal, is inadmissible, as its effect would be to convey land by parole in contravention of the statute of frauds.—Harris v. Oakley, 7. N. Y. S. 232.

THOMAS LOVE.

IT is with pain and regret that the secretary announces to the Society the death of one of its early members, Mr. Thomas Love. He was born near Hillsboro, Loudon County, Virginia, September 8, 1810. His parents were strict Quakers, or Friends, as they called themselves, and he was raised in that faith. In 1829 he attended the inauguration of Gen. Jackson, as President of the United States. He was in Ohio in 1830, and soon after came to Michigan and settled at Berrien Springs, where he was engaged in mercantile business for several years. He was Deputy County Treasurer of Berrien County from 1838 to 1840: in the latter year he was elected County Treasurer as a Whig, while the Democrats had a majority of one hundred on the general ticket. In 1844 he was elected County Clerk and held the office two terms. After this he went into the lumber business near Berrien. In 1854 he located at Avery, and, in company with another gentleman, built a saw mill which did a large business for many years, after which he engaged in farming and surveying. He was twice elected County Surveyor—in 1872 and 1874—and held various township offices. He was an efficient and popular officer, and was several times elected over adverse party majorities. He made a survey of the city of Niles and did his work so thoroughly that the surveys and monuments in that city are in the best condition of any city or village with which the writer is acquainted. He was agent for the Michigan Central Railroad at Avery for thirty years, and American Express Agent for twenty-five years or more. He was one of the founders of the Michigan Engineering Society, and always took a most active interest in it till the last. He did a large amount of work in the collection of material for the Manual of Land Surveying, and did everything in his power to advance the interests of the society. His dues were always paid in advance, and an extra dollar generally came with it. One of his last acts was to send the timber scribe to the writer for exhibition at the Detroit convention; he was then unable to sit up, and knew that he should never meet with us again. He died February 24, 1890, from old age, without disease or suffering. He was a gentleman of the old school, affable and courteous at all times. In the words of one nearest and dearest to him, "He was an honest, upright man, conscientious and truthful; what more can I say than that he was a gentleman in every sense of the word—one of nature's noblemen?"

F. HODGMAN.

THE ELEVENTH ANNUAL CONVENTION.

The eleventh annual convention of the Michigan Engineering Society was held at Detroit, January 21, 22 and 23, 1890. Owing to the general prevalence of *La Grippe*, a very considerable number of the members were absent who would otherwise have been in attendance. The earlier sessions were held in Philharmonic Hall, but on account of the light attendance it was concluded to hold the later sessions at the Plankinton hotel. A stenographer was employed to report the proceedings, but his report when received proved to be of very little value, and for this reason we are unable to publish any considerable part of the discussions. For the same reason Mr. Reed's description of work on the St. Clair tunnel is omitted. The business meeting of the convention was held on Thursday afternoon. The report of the secretary was read and accepted. The following is the report:—

SECRETARY'S REPORT.

I herewith submit the following report of business transacted for the Society since the last annual meeting. Everything up to the close of the convention at Lansing has been placed in the hands of every member of the Society in the columns of the Annual, and I do not deem it necessary to repeat it. In accordance with the orders of the Society, amendments to Article 3 of the Articles of Association were signed by the directors and filed in the office of the Secretary of State. The annual meeting of the Board of Directors was held at Hotel Downey, in the City of Lansing, October 9, 1889. There were present President Steele, Secretary Hodgman, Directors Cooley and Appleton. The meeting was called to order by the President and the ballots for officers canvassed. The following candidates, having received a majority of the ballots cast for the respective offices, were declared elected:—

President—R. C. CARPENTER.

Vice President—J. H. FORSTER.

Secretary and Treasurer—F. HODGMAN.

Directors—G. E. STEELE, M. E. COOLEY and C. E. GREENE.

The annual report of the Secretary was read and accepted. The directors examined the report and accounts of the Secretary and by M. E. Cooley reported that they found them correct.

The following is the report:—

SECRETARY'S REPORT FOR 1889.

I have to report the following business transacted by me for the Society since the last annual meeting:—

The first business after that meeting was to complete the program and make preparations for the annual convention. The list of papers selected at the annual meeting was provided for, as far as it was possible for the Secretary to do so. Circulars of invitation to civil engineers and surveyors throughout the State were prepared and sent to all whose addresses could be procured. A concession of special rates for the convention was secured from the Michigan Railway Association. The local arrangements for the convention were provided for by the Lansing members. It is not necessary to speak of the very successful convention which was held. At its close bids were solicited from various firms for the publication of the annual report. The job was let to the Review and Herald Printing Company of Battle Creek, on a basis of $240 for 1000 copies of 150 pp. each. Extra pages to be $1.25 per page, and cuts and extra work to be paid for by the Society. The report was out in May, and I took the liberty to christen it the Michigan Engineers Annual.

Letter ballots for new members and for officers were sent out early in the year, and the ballots for new members canvassed by me in time to include their names in the Annual. Certificates of Membership were made out and mailed to all new members the 1st of June. One copy of the Annual was mailed to each member of the Society not in arrears for dues, as soon as it was out. Copies were sent to others at subsequent times as fast as their dues were paid. Copies were also sent to all of our advertising patrons. Exchanges of reports have been effected with the Societies of Arkansas, Iowa, University of Michigan, and with the Provincial land surveyors and Dominion land surveyors of Canada. I have written the secretaries of the Missouri and Ohio Associations without getting any reply. The Indiana reports are late, but we expect them some time soon.

A good proportion of our income is derived from our advertising patronage, and without it our annual reports cannot be made what they have been. The Secretary has labored diligently both to secure such patronage, and to make the reports worthy of it, and I wish to especially acknowledge my obligations to Mr. Geo. L. Wells for the assistance he has rendered. If the members generally had been the tenth part as willing and helpful as Mr. Wells has been, we should have had the means of adding greatly to the value and attractiveness of our Annual. As agreed upon in the convention, the proceeds of a special contribution by the members was used to secure a portrait of Ex-President J. B. Davis. This was procured of the Eastman Dry Plate Company of Rochester, from a negative taken in Ann Arbor.

Some time a o a communication was received from a committee of the American Society of Civil Engineers, requesting the appointment by this Society of a committee to confer with them on the subject of preparing a plan of affiliation with the American Society, the committee to report to that Society by the 1st of November. I replied to the communication, notifying the writer of the time and place of our annual meeting, and requesting further information in regard to what the American Society desired. No reply has been received.

Notice of the annual meeting has been sent to each member of the Society, with a request for a response to it relative to place of meeting, subjects for discussion at the next convention, etc. I herewith submit such responses as I have received.

I also submit the following in regard to the finances of the Society:—

RECEIPTS.

On hand October 10, 1888	$ 111.85
Received from advertisers to October 9, 1889	234.95
Received from members for dues	221.00
Received from members for portrait fund	43 62
Received for Reports sold	7.25
From Wm. Appleton	50
	720.17

EXPENDITURES.

Paid balance on 1888 Reports	$ 92.04
Paid 1889 Reports and Portrait	359.57
Paid Stenographer	35.00
Paid Secretary's Salary 1888	50.00
Paid for Expenses on 1889 Reports	13.50
Paid for Stationery and Postage	48.44
Paid for Printing	27.08
Paid Expenses of Directors at Lansing	9.67
Paid for Express and Freight	12.30
Paid for American Digest	10.00
Paid for R. R. Certificates	1.00
Balance on hand October 9, 1889	61.57
	720.17

There is also due the Society from members for membership fees and dues and advertising $45.35.

No reports have been sent to members who are indebted to the Society, with the exception of new members who are only indebted for the senior membership fee. F. HODGMAN, *Secretary.*

The Secretary filed notices of sundry proposed amendments to the constitution and by laws. It was voted to hold the next convention at Detroit, beginning January 21, 1890, and the members in Detroit were appointed a local committee of arrangements.

The Secretary presented a list of topics furnished by members of the Society for discussion at the next convention, including papers promised by several members.

It was voted that the Secretary prepare the program for the convention.

The Board of Directors then adjourned. F. HODGMAN, *Secretary.*

Since the meeting of the Board of Directors I have endeavored to the best of my ability to carry out their wishes in preparing for this convention. In view of the repeated refusals of the Michigan Railway Association to grant reduced rates to Society meetings of various sorts, I did not deem it worth while to apply for special rates to this convention. I have made partial arrangements for printing the next number of the Annual, and have done something toward securing advertisements for it. Here I wish to repeat what has been said several times before, that it is very desirable that all the members of the Society who can, should co-operate with the Secretary, or publishing committee, in securing advertising patronage. Upon the amount of advertising secured, very largely depends the quality of the reports sent out as well as the number published. It was very much desired to publish in the last Annual a number of cuts illustrating the papers. It would add very much to the value and attractiveness of our Annual if we could with each number publish cuts illustrative of engineering work performed during the year by our members or others, and if we could have them from photographic negatives taken by ourselves so much the better. It is desirable to increase the circulation of our Annual by increasing

the number of our exchanges, thus increasing the value of the Society to each member by the additional amount of engineering literature furnished, and at the same time increasing the value of the Annual as an advertising medium. Something of this would have been done the past year if the finances of the Society had permitted, but it was thought better to keep entirely within our means, and incur no obligations that we were not sure of the means to meet. So we want each one of you to do what you can to secure advertising patronage; and not only that, we want you to help to keep that patronage by making it worth the while of these firms to advertise with us, by patronizing them in turn whenever we have the opportunity.

The late numbers of our report have been copyrighted. I think it would have been to the advantage of the Society if it had been done from the first. Authors all over the country have been using our work without giving us credit for it. If it is of value to them, they should pay us for it. In this connection I would suggest the question as to whether it might not prove profitable to the Society to classify the papers which have been published in the Reports and publish them in book form in several small volumes. F. HODGMAN.

Since writing the foregoing, I have received the proceedings of the Ohio Society of Engineers and Surveyors, and mailed them to all members of the Society not in arrears for dues. With them I sent the Dominion Land Surveyer's Report, which, by an oversight of my assistant was not included with the other reports when sent out. The Indiana report is the only one of our exchanges which has not been received. I learn that it has not been published but goes over to be published with the 1890 reports. After the past year's trial, I am inclined to think it is not the better way to send out reports by express at the members' expense unless they furnish the money to prepay charges. If this were done they could be sent to most of the members at a trifle less than by mail if sent in packages of four pounds or less. The postage is the second largest bill the society has to meet. It amounts to nearly $15. on the Dominion and Ohio reports just sent out. In connection with the photographic work of the Society it seems that it would be a good plan to have an exhibit at our next meeting of photographs by the members of the Society, and if we can also have a lot of lantern slides illustrating the work done by our members it would be a very valuable and attractive part of our program. Can we not have them?

The *Engineering News*, the *Railroad and Engineering Journal*, and the *American Engineer*, have been sent to the Society during the past year in exchange for our Reports. Every engineer should have one of these journals, and all of them, if he can afford it.

F. HODGMAN, *Sec'y.*

The following Amendments to the Constitution and By-Laws, which were submitted to the Board of Directors at their annual meeting, were submitted to the convention and adopted:—

AMENDMENTS TO CONSTITUTION.

ARTICLE II.

SECTION 1. The officers of this Society shall be senior members. Nominations for office shall be made at the annual convention. Election shall be by letter ballots, which shall be submitted to the Society previous to the next annual meeting of the Board of Directors. The ballots shall be canvassed and the result announced by the Board of Directors at their annual meeting. Officers of the Society shall hold their respective offices until the close of the annual meeting of the Board of Directors, and until their successors have notified the Secretary of their acceptance of the offices to which they have been elected.

ARTICLE IV.

Amendments to the Constitution shall be presented in writing at the annual convention, and submitted to the Society by letter ballot previous to the next annual meeting of the Board of Directors. The Ballot shall be canvassed, and the result ascertained and announced by the Board of Directors at their annual meeting.

AMENDMENTS TO BY-LAWS.

BY-LAW No. 3.—*Relative to applications for membership.*—The applications must be favorably indorsed by at least one member of the Society from personal knowledge, and be accompanied by a fee of $3.00. The application and fee shall be delivered to the Secretary, who shall refer the application to the Board of Directors for examination and approval. If approved by them, the Directors will determine to what class the applicant is eligible, and endorse their approval and classification on the application, which shall be submitted to the Society for action by letter ballot. Five adverse ballots shall reject a candidate. In case of the rejection of a candidate, the Secretary shall immediately return the fee to the applicant. If the candidate is elected, he shall sign the constitution, and if elected a senior member, shall pay the further sum of $2.00 as a membership fee. No additional fee shall be required from junior members. When a candidate is elected to membership, the Secretary shall give him notice to that effect, and upon receipt of the fee as above provided, shall issue to him a certificate of membership.

Letter ballots for members shall be issued to the Society by the Secretary on the first Monday in March of each year. The ballots shall be canvassed by the Secretary and the result announced to the candidates for membership on the first Monday in April of each year.

Candidates who have been elected to membership and fail to pay the membership fee within thirty days after being notified of their election, shall forfeit their membership and the application fee. The Board of Directors may extend the time for payment in any instance where satisfactory reasons are shown therefor.

BY-LAW No. 5.—Members desiring to withdraw from the Society shall make application in writing to the Secretary, paying all assessments and dues to the Society up to the time when the application is presented. The application shall be referred to the Board of Directors, who shall determine whether the application shall be granted or refused.

No member shall be liable to pay any dues or assessments levied after the time when his application for withdrawal is received by the Secretary until it is passed upon by the Board of Directors.

The following persons were nominated for officers for the next year:—

For President—R. C. CARPENTER, Lansing.
JOSEPH RIPLEY, Sault St. Marie.
J. B. DAVIS, Ann Arbor.
WALTER S. RUSSEL, Detroit.

For Vice-President—GEO. L. WELLS, Cadillac.
J. H. FORSTER, Williamston.
E. DENNIS, Jackson.

For Secretary and Treasurer—F. HODGMAN, Climax.

For Directors—GEO. L. WELLS, Cadillac, M. E. COOLEY, Ann Arbor, W. B. SEARS, East Saginaw. C. E. GREENE, Ann Arbor, GEO. E. STEELE, Traverse City, S. E. JARVIS, Lansing.

Applications for membership were received from the following persons and approved by the Board of Directors for Senior members:—

ADOLPH BARTHEL, Detroit, Mich.
G. S. WILLIAMS, " "
E. H. MUMFORD, " "
FRANK S. BIGLER. " "
MILO DAVIS, East Tawas, Mich.

The thanks of the Society were voted Mr. Walter S. Russel for the very acceptable manner in which he had provided for the local wants of the Society; to Mr. Clark, proprietor of the Plankinton Hotel, for many courtesies extended; to the Eastman Company of Rochester, for their exhibit of instruments, and to their representative, Mr. C. A. Stacey, for his demonstration of the manner of using the camera and making bromide prints. On motion of Mr. Forster, the sum of $50 was voted to the Secretary, in recognition of his services.

Mr. Livingstone read a paper, giving the results of tests of the engines of the steamer T. W. Palmer, during one of her regular trips.

Mr. Hyde exhibited some fine drawings and blue prints, and explained methods used in preparing them. The papers of Messrs. Livingston and Hyde were not furnished the Secretary for publication. The Society adjourned *sine die* on Thursday evening.

SUGGESTIONS OF THE SECRETARY.

1. When letter ballots are sent you, read the instructions and prepare your ballot in the manner directed, or you are liable to lose your vote, as many have done by their carelessness.

2. Have you done anything for the Society except to pay your fees and dues? If not, let us have a paper from you at the next convention. The active members of the Society are not doing their work for the $2 a year dues. They want the thoughts and experiences of others in exchange for their own.

3. Photographs are excellent for preserving records of engineering work. Let us have an exhibit at the next convention.

4. Lantern slides furnish the most satisfactory means of exhibiting views. They are not hard to make. Let us have an exhibit of views of our own make at the next convention.

5. What subjects would you like to have discussed at the next convention?

6. Notify us when you change your address. It may save your Reports from being lost.

7. The revenue from advertisements assists very materially in getting out a good Annual. One good turn deserves another. Patronize those who patronize us. They are all worthy of our patronage. Make it an object for them to continue their advertisements from year to year.

8. I have purchased the interest of Prof. Bellows in the Manual of Land Surveying, and am getting ready for another edition. What improvement can you suggest, to make it better?

9. Wanted, for the next edition of the Manual, the best and most practical solution of the following problem in surveying. Send us your solution right away.

The field notes of the line of a highway read as follows:—

Commencing at Meander Post No. 5, on the north bank of Kalamazoo River and running thence 1st *N.* 62° *E.* 14.00 chains; 2nd *N.* 43½° *E.* 8.00 chains; 3rd *N.* 5° *W.* 12.00 chains; 4th *N.* 72½° *E.* 10.25 chains; 5th *S.* 12° *W.* 6.43 chains to a stone set for Meander Post No. 3.

I commence at Meander Post No. 5, and with variation 2° 17′ *E.*, run a random line according to the field notes, setting temporary stakes at each angle in the line, and come out 62 links east of Meander Corner Stone No. 3.

1. What is the correction for the variation of the needle?

2. What is the correction for the stake at each angle, and how shall I find it?

OFFICERS FOR 1890.

President—R. C. CARPENTER, Agricultural College, Mich.
Vice-President—J. H. FORSTER, Williamston, Mich.
Secretary-Treasurer—FRANCIS HODGMAN, Climax, Mich.
Directors—M. E. COOLEY, Ann Arbor, Mich.; C. E. GREENE, Ann Arbor, Mich.; GEO. E. STEELE, Traverse City, Mich.; and the President and Secretary, *ex-officio*.

LIST OF MEMBERS.

SENIOR MEMBERS.

ALLEN, JEROME, Surveyor, Milan, Monroe Co., Mich.

APPLETON, WILLIAM, Civil Engineer, and Brick Mft., Lansing, Ingham Co,. Mich.

AMES, GEO. M, Assistant City Engineer, Grand Rapids, Kent Co., Mich.

BAILEY, M. H., Surveyor, Dimondale, Eaton Co., Mich.

BRADT, J. C., Surveyor, Marcellus, Cass Co., Mich.

BALDWIN, WILLIS, Surveyor, Monroe, Monroe Co., Mich.

BARRINGTON, EDWARD, Civil Engineer, Lock Box 58, Georgetown, D. C.

BARTHEL, ADOLPH, Mechanical Expert and Solicitor of Patents, Detroit, Mich.

BECKMANN, L., Manufacturer Surveying Instruments, Toledo, Ohio.

BEDEN, SETH N., Surveyor and Civil Engineer, Pine Run, Genesee Co., Mich.

BELLOWS, C. F. R., Prof. Math., Mich. State Normal School, Ypsilanti, Washtenaw Co., Mich.

BLAIR, JAMES, Surveyor and Drainage Engineer, Morenci, Lenawee Co., Mich.

BEAN, HENRY F., Civil Engineer, Jackson, Jackson Co., Mich.

BIGLER, FRANK S., Civil Engineer and Commercial Traveler, Detroit, Mich.

BROWN, F. H., Surveyor, Sault Ste. Marie, Chippewa Co., Mich.

BROWN, GEO. M., Roadmaster F. & P. M. R'y, East Saginaw, Saginaw Co., Mich.

COX, GEORGE, Civil Engineer, Kearney, Neb.

CORYELL R. J., Surveyor, Jonesville, Hillsdale Co., Mich.

CAMPAU, THOMAS, Surveyor, Detroit, Wayne Co., Mich.

COOLEY, M. E., Prof. Mech. Eng., Univ. of Mich., Ann Arbor, Washtenaw Co., Mich.

CARPENTER, R. C., Prof. Math. and Eng. Agricultural College, Ingham Co., Mich.

CARPENTER, L. G., Prof. Eng. State Ag'l. College, Fort Collins, Col.

CARLETON, GUY H., Sault Ste. Marie, Chippewa Co., Mich.

CAVIS, C. H. V., Engineer D. S. S. & A. R'y, Marquette, Marquette Co., Mich.

CORNWELL, CLARK, Paper Manufacturer, Ypsilanti, Washtenaw Co., Mich.

CHILDS, ADDISON, Asst. Eng. State Capitol, Lansing, Ingham Co., Mich.

CUMMINGS, GEO. P., Surveyor and Civil Engineer, Marquette, Marquette Co., Mich.

COLLAR, H. A., City Engineer, Grand Rapids, Kent Co., Mich.

COATS, WM. R., Hydraulic and Sanitary Engineer, Kalamazoo, Kalamazoo Co., Mich.

CLARK, JOHN M., Car Manufacturer, Howell, Livingston Co., Mich.

CALLARD, J. L., Civil Engineer, Sault Ste. Marie, Chippewa Co., Mich.

DAVIS, GEO. L., Civil Engineer, Cadillac, Wexford Co., Mich.

DAVIS, L. M., Civil Engineer, Gladstone, Mich.

DAVIS, J. B., Asst. Prof. Civil Engineering, Univ. of Mich. Ann Arbor, Washtenaw Co. Mich.

DAVIS, MILO, Civil Engineer, East Tawas, Mich.

DENNIS, E., Mechanical Engineer and Manufacturer, Jackson, Jackson Co., Mich.

DEAN, SETH, Civil Engineer, Glenwood, Iowa.

DENNISON, C. S., Prof. of Drawing, University of Mich., Ann Arbor, Washtenaw Co., Mich.

DREW, ALBERT L., Surveyor and Real Estate, Three Oaks, Berrien Co., Mich.

DUNBAR, E. L., Chief Engineer and Supt. of Water-Works, Bay City, Bay Co., Mich.

DOANE, GEO. W., Surveyor, Gladwin, Mich.

DURAND, W. F., Professor of Mechanics, Agricultural College. Ingham Co., Mich.

DOUGLASS, BENJ., Bridge Engineer, M. C. R. R., Detroit, Wayne Co., Mich.

EATON, ALBERT, Surveyor and Civil Engineer, Glenn, Allegan Co., Mich.

FRENCH, E., Civil Engineer, Battle Creek, Calhoun, Co., Mich.

FORSTER, J. H., Civil Engineer and Stock-Grower, Williamston, Ingham Co., Mich.

GARDNER, ALBRO, Civil Engineer, Seattle, Washington Ter.

GILLETTE, O. C., Civil Engineer, Medina, N. Y.

GIFFORD, JAMES M., Surveyor, Duck Lake, Calhoun Co.. Mich.

GOODALE, O. C., Surveyor, Chesaning, Saginaw Co., Mich.

GRANVILLE, J. J., City Engineer, East Saginaw, Saginaw Co.. Mich.

GREENE, C. E., Prof. Civil Engineering, Univ. of Mich., Ann Arbor, Washtenaw Co., Mich.

GREINER, R. C., Civil and Architectural Engineer, Denver, Colo.

GUILD, E. F., Real Estate Dealer, East Saginaw, Saginaw Co., Mich.

GUILEY, D. E., Surveyor and Civil Engineer, East Tawas, Iosco Co., Mich.

HAYES, ELI L., Surveyor and Map Publisher, Reed City, Osceola Co., Mich.

HEMINGWAY, L., Surveyor and Civil Engineer, Benton Harbor, Berrien Co., Mich.

HODGMAN, F., Surveyor and Civil Engineer, Climax, Kalamazoo Co., Mich.

HOLMES, CHARLES, Surveyor and Civil Engineer, 501 S. Park St., E. Saginaw, Saginaw Co., Mich.

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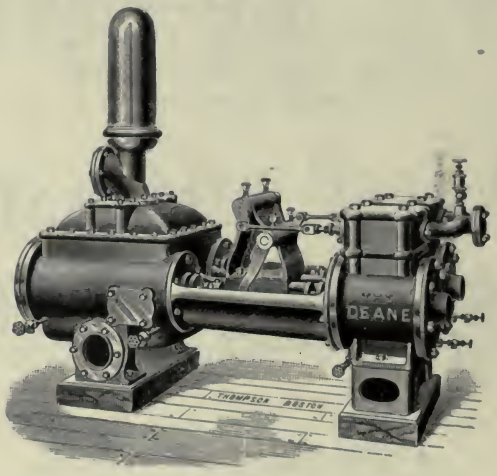

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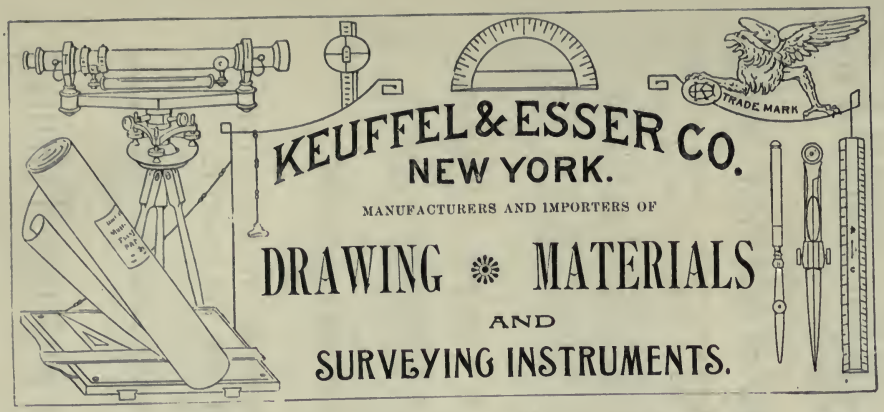

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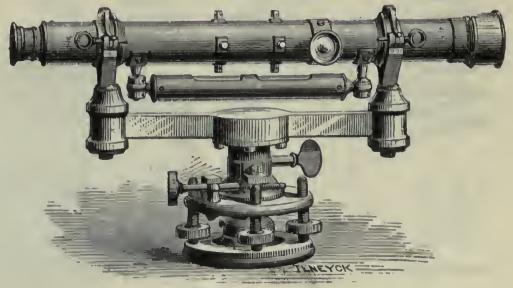

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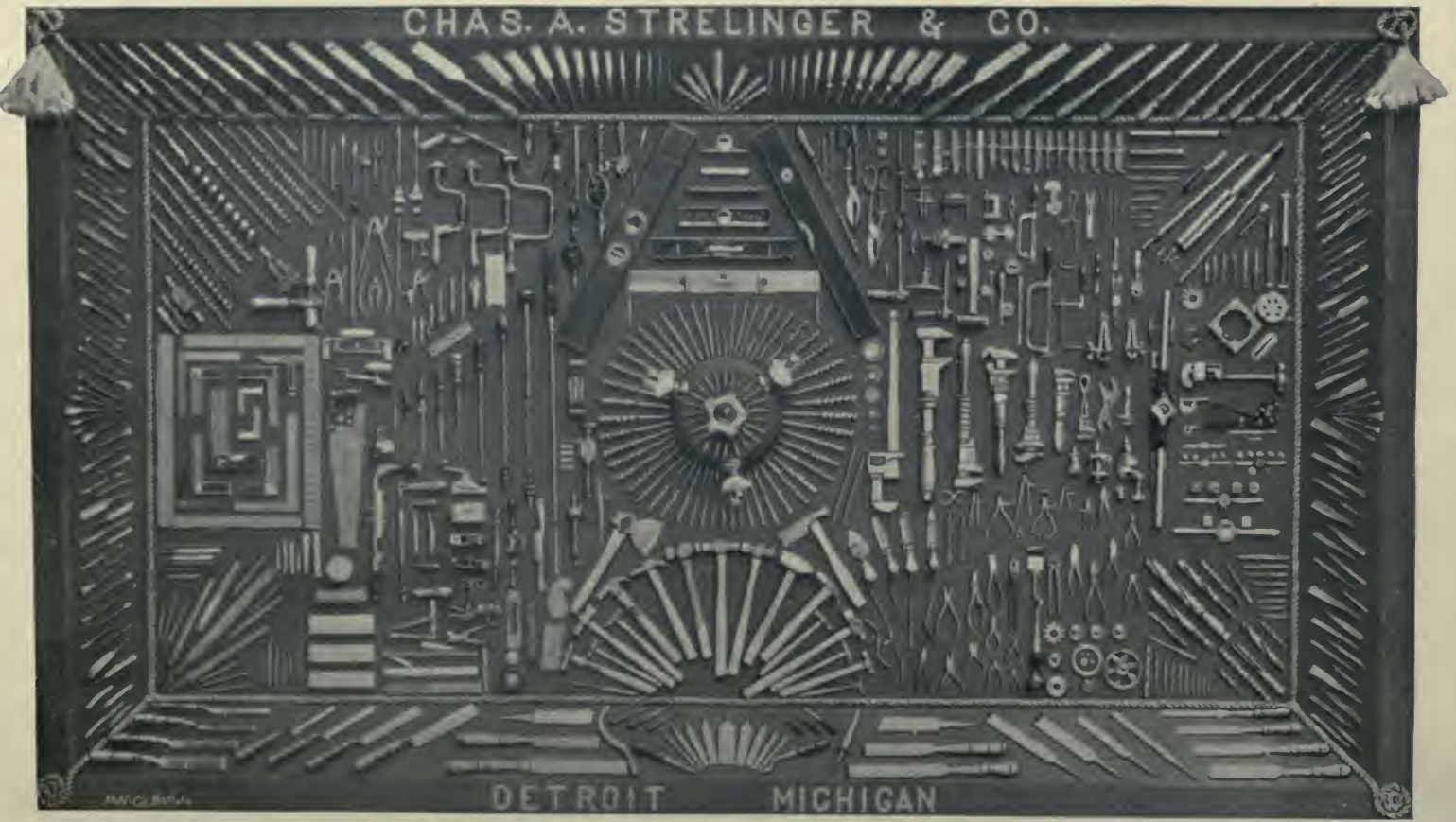
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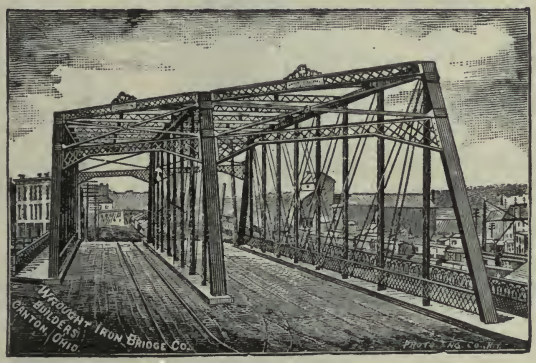

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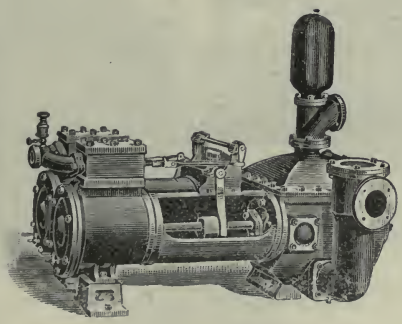

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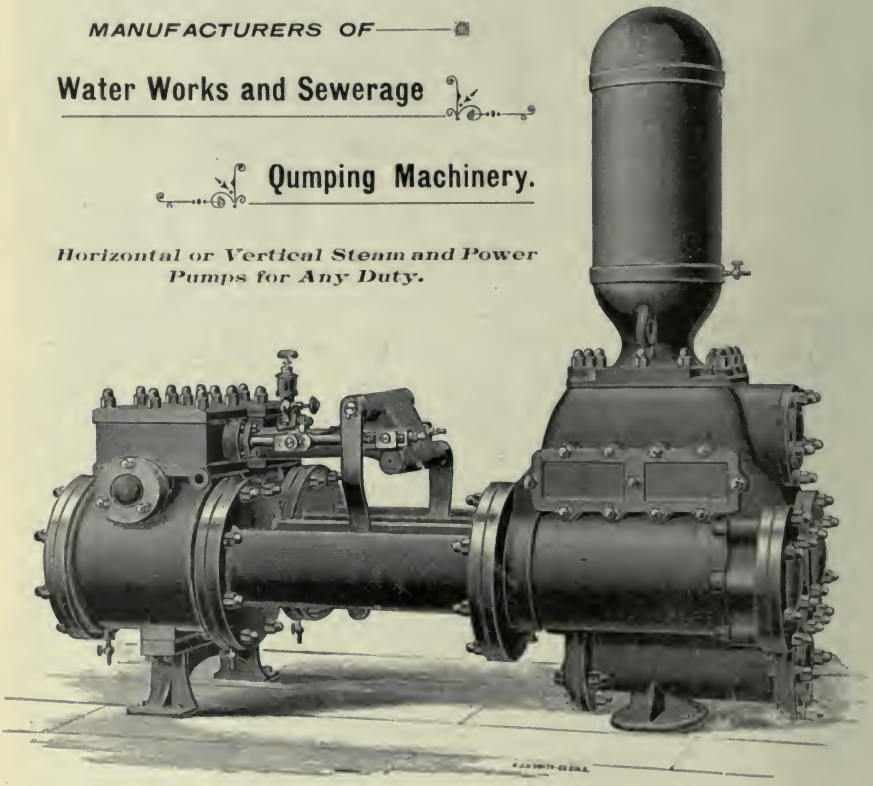

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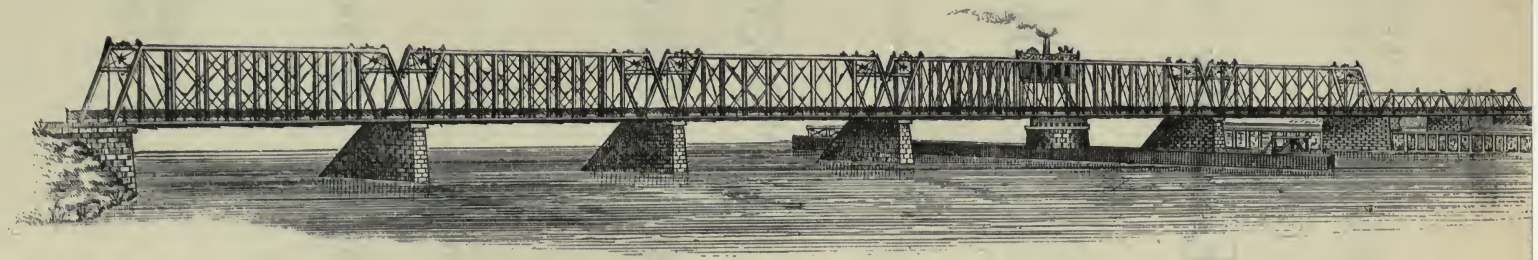

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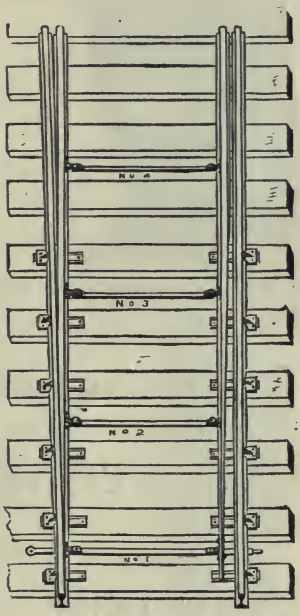

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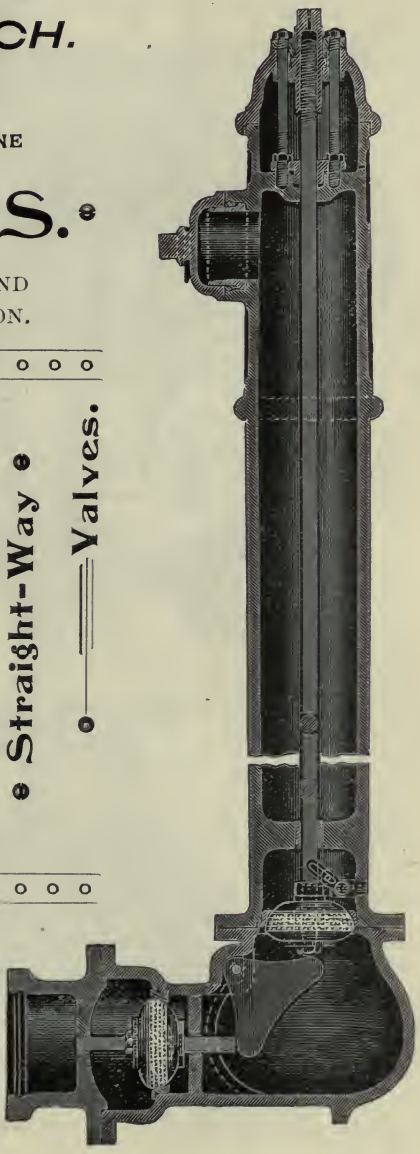

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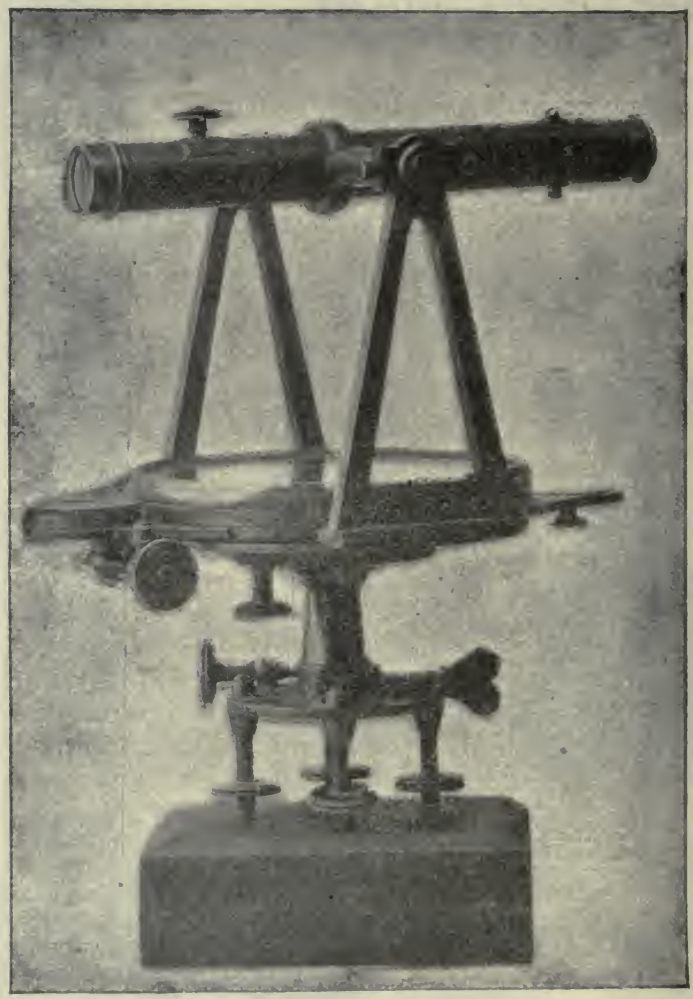

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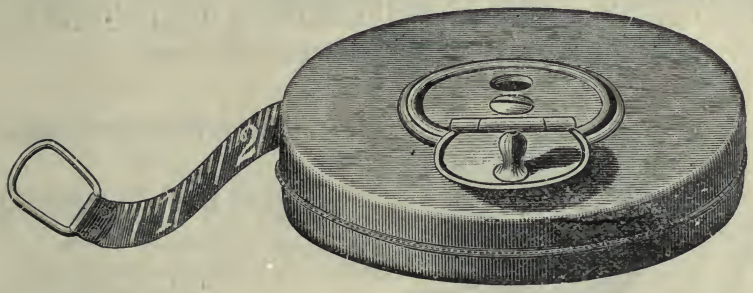

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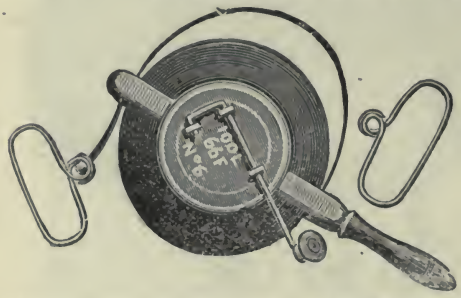

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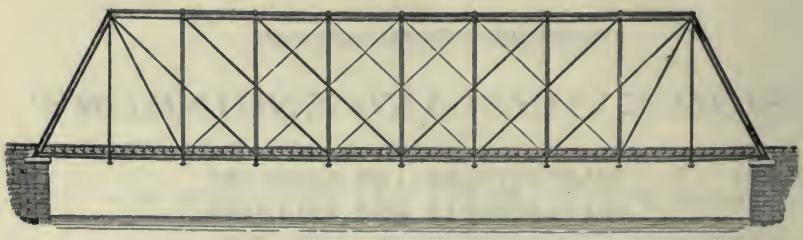

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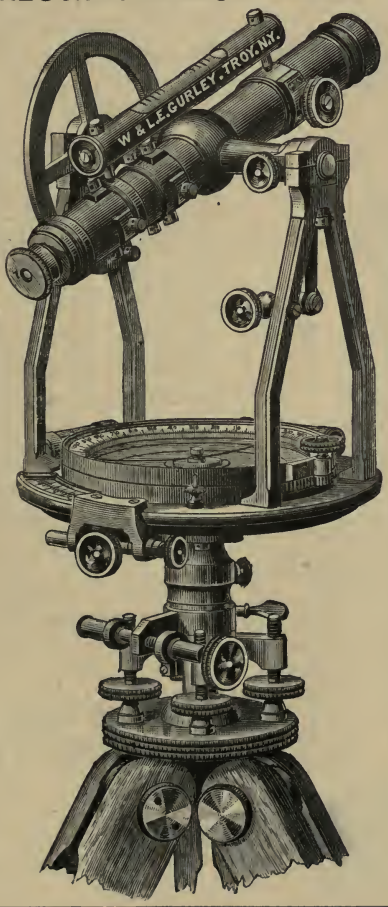

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